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CATTLE FEEDING

WITH

SUGAR BEETS, SUGAR, MOLASSES

AND

SUGAR BEET RESIDUUM

BY

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To

DR. HARVEY W. WILEY,
CHIEF CHEMIST OF THE U. S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.,

MY FRIEND AND CO-WORKER,

WHO DURING THE PAST TWENTY YEARS

HAS GIVEN HIS OFFICIAL AND SCIENTIFIC SUPPORT

TOWARD THE PRACTICAL REALIZATION OF THE INTRODUCTION OF THE

BEET-SUGAR INDUSTRY INTO THE UNITED STATES,

THIS WORK IS RESPECTFULLY DEDICATED BY

THE AUTHOR.

260275

PREFACE.

THE author for many years past has felt convinced that the future success of the American beet sugar industry would depend upon the introduction of certain principles of economy that are not entirely in accordance with our customs. The utilization of waste is an issue that always appeals to countries where labor is cheap and the struggle of life is hard. In the United States it is only within the past two years that any serious attention has been given to feeding the residuum cossettes to cattle or finding some use for the molasses remaining after the campaign has ended. There is no doubt but that a large number of the European beet sugar factories would have long since ceased to exist had the residuums, pulp and molasses not been sold and thus become the sole money returns for the investors. In years when general prosperity prevails this income is that much more to be added to the general profits which frequently during a single campaign reach a total of 80 per cent. on the invested capital.

In 1874 when the beet sugar agitation in the United States was begun, not a single acre was planted in beets and no beet sugar factory was working in this country; the seeds imported were distributed in many states and the resulting beets were analyzed. There remained on the farmers' hands several tons of beets which had at first to be paid for out of the personal pocket of the writer: it was urged that a reasonable trial be given to these roots for feeding purposes; this was done, and excellent results followed. Subsequently, the seeds of many varieties, which were gratuitously distributed, had no difficulty in finding some willing tillers to give them a fair trial. This led to solutions of difficult issues among farmers who had furnished beets to several of the early Canadian beet sugar factories, when the inferior quality of the beets caused their refusal at the factory; discouragement followed and many of the farmers cancelled their contracts and turned their attention in other directions. It was not long before it was realized that while $4.00 to $5.00 per ton could not be obtained at the factory for roots testing less than 10 per cent. sugar, on the other hand for feeding purposes they would be worth at least $3.50 as shown by the increase in milk, butter, etc. Some farmers have gone so far in this direction as to devote a certain area to beets every year since that time, while the Canadian factories that were working in 1883 have now ceased to exist. During the interval of twenty years sugar beets have continued to be fed with excellent results in certain districts of Canada. In the United States root feeding to cattle is not as general as it should be and the farmers have thus wasted an opportunity. General information in regard to pulp feeding has been wanting, so it was considered urgent to visit most of the European farms and examine the question on the spot, and this present volume has been the result of that investigation. Of recent years in Continental Europe molasses feeding to cattle has gained in popularity. All the available documents on the subject in both French and German have been consulted and the practical results where this residuum has been regularly fed have been personally observed. Sugar may be had at such a low figure that it is interesting to examine just within what limit it also may be used for cattle. The theory of cattle feeding and requisites for success as considered from the standpoint of the leading German authorities such as Wolff and Kühn, have been studied in detail, also the theories of many of the French savants upon the same subject. As the U. S. Department of Agriculture at Washington and the numerous experiment stations of the country have devoted considerable time to cattle feeding, their publications have been consulted and from them certain conclusions have been drawn that are not always in strict accordance with the theories of some of their experts. The results of the writer's personal practical experience is also given in these pages.

As many technical terms are used there is given as Part VI a special chapter of definitions and technical considerations, which enables any person without special scientific training to thoroughly understand the entire question discussed. The main object in view is to prevail upon farmers to use either sugar beets, sugar, or sugar beet residuum in its varied forms; by so doing they will have within their reach a source of profit hitherto ignored.

L. S. WARE.

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CATTLE FEEDING WITH SUGAR BEETS, SUGAR, MOLASSES, AND BEET RESIDUUM.

INTRODUCTION.

General Considerations on Cattle Feeding.

Former modes.

In the United States, as in most countries during their early development, the *Cow* was considered of secondary importance in general agricultural economy. However, of recent years, through the researches of the Department of Agriculture and the agricultural experiment stations of the various States, great progress has been made.

It must not be forgotten that not many years since cattle in general on the average European farm were kept to utilize the waste that the farmer might have at his disposal before or after harvesting his crops. Consequently live stock on hand received a forage that was the outcome of the crop harvested, without regard to whether or not it was exactly suited to the animal fed.

For a long period of years the question of feeding animals with the idea of keeping them in the best of health and at the same time fattening them for the benefit of the owner was, to a certain extent, a problem almost unknown. The average person had some ideas concerning the digestive and assimilative processes of the animal being fed, but upon general principles it may be said that these ideas were erroneous. Although the quantity of feed entering the daily ration was increased, its actual cost was too frequently overlooked; consequently the results realized were not commensurate with the money outlay. Where a cow was formerly fed with the sole idea of maintaining the fertility of the soil, it was frequently found that the ultimate cost of such a fertilization rendered the plan far from remunerative. In this country it is the exception for manures to be the main object in view.

Present modes. At the present day all these uncertainties have been set aside by the rational introduction of scientific modes of feeding, based upon the physiology of the animal, combined with strict rules of hygiene, and above all by the study of the nutritive value of each element used.

The agricultural chemist, and the chemists connected with the sugar factories, have accomplished this work almost alone, struggling against the routine which was always opposed to these results, and pointing out that the farmers, controlled by their prejudices, were in the wrong. They, on the other hand, declared that the theoretical man was announcing or enunciating wrong ideas and that the animal itself was the best guide as to the elements that his daily life required. However, science has triumphed in the struggle.

These studies have related to the transformation of forage into fatty substances, into muscles, tendons, flesh, hair, wool, milk, urine and excrements. They furnish, besides, a complete study of various forages, the effects of which one could almost determine in advance. There is, however, in this work something lacking, namely, the complete individual study of the animals being fed; also the manner in which the special product being tested is assimilated.

It is at the present time recognized that there is no feed that may be considered universal, that is, which contains all the nutritive elements supposed to be necessary for the healthy maintenance of the organism of animals. Hay, however, comes nearest the ideal forage, and for this reason it is taken as the standard of the nutritive value of forage in general.

Constituents of fodders. The chemical composition of a forage permits one to ascertain within what limits the proposed results may be obtained. For example, nitrogenous constituents are for the production of proteid substances, and consequently the muscular tissues. During the transformation of their molecules they develop a certain force which is utilized by the changes which occur in the body. The resulting products are burned through the intervention of the air inhaled through the lungs, and constitute what is in fact an actual heat. Their direct action in the formation of fat is not as yet satisfactorily understood. The non-nitrogenous substances combine with the excess of oxygen remaining after the combustion of the products of dissimilation of the tissues, and these also give animal heat. They are the substances which form the fat.

If the quantity of nitrogenous substances is greater than is necessary to make good the losses of the tissues, and if the quantity of non-nitrogenous substances is greater than that which has been burned by the oxygen absorbed by the blood, what remains is deposited as adipose tissue. The transformation of nitrogenous substances, in cases of insufficiency in the supply of non-nitrogenous substances, becomes a source of supplementary heat, and thus forms an additional factor towards the supply of the non-nitrogenous substances, which have been deficient; then follows a carbonation when brought in contact with the oxygen of the blood, instead of forming muscular tissues, which is their real function.

Standards of feeding.

If one accepts the standards now generally admitted for nitrogenous substances, their nutritive value is 3.5 times superior to that of the non-nitrogenous substances, and such being the case one can readily understand the mistake made in foolishly wasting material that is in reality of great value in obtaining the result which it is possible to realize at less expense with the non-nitrogenous substances. Under all circumstances animals should receive a proportion of nitrogenous and non-nitrogenous constituents, such that the substances requisite for the production of heat shall be reduced to a minimum, as it is only then that these constituents can perform the work asked of them in the repair of the waste of muscular tissues. The amount of non-nitrogenous substances should be sufficient to produce the fatty tissues besides exercising other valuable functions.

The excess of nutrients which may be utilized in either of these ways is eliminated from the body without any benefit to it. The best results are obtained in giving to an animal the greatest amount of dry matter that can be assimilated, while at the same time the minimum limit of nutritive substances eliminated without benefit is secured and the digestive faculty of the stomach is not reduced. All non-nitrogenous substances have for their object the maintaining of the heat of the animal's body, which heat would otherwise be produced at the expense of the proteid substances. Under circumstances of judicious feeding there follows an economy rather than an expenditure of the nitrogenous substances.

Importance of fat. The fat has for its special object the increase of the adipose tissues; it increases the assimilation of other nutrients and is an indispensable element. As for the cellulose—its principal object is to give to nutrients the consistence requisite for the intestinal assimilation of the animals to which it is fed. Furthermore, according to Tollens, it contributes to nutrition and is first transformed into pentosanes, which may be assimilated by the organism. The proportion of these substances should be suited to the case under consideration in order to obtain a good digestion and consequently a satisfactory assimilation, and also in order to have a profitable fattening and flow of milk, as well as the maximum of work, as the case may be.

Role of cellulose.

Importance of salt. Salts have the object of fortifying the bony tissues and repairing the losses of the body. They furthermore render elements in general more palatable. Ordinary salt, for example, increased in reasonable proportions, will be most acceptable and agreeable. It, moreover, plays an important role as an assimilating element, and has an important influence on the exterior appearance of animals in general. Hulwa recommends that cattle consuming considerable quantities of residuum cossettes from beet-sugar factories, have lime added to their daily rations; it may be given as chalk or in other forms, about 20 to 40 grams for each horned animal, but only 10 grams to swine.

Role of water. The bodies of animals in general represent at least two-thirds water which is used for the transfusion of the nutritive elements through the entire organism. It constitutes, consequently, an important factor in the assimilation. An excess of water is deleterious, as it increases the heat of the body, owing to its evaporation through the lungs and the skin. It is probable that this excess increases the heart's action. Under all circumstances it has an influence on the assimilation and dissimilation of the proteid substances of the organism and may result in a dropsical transformation of the cellular tissues.

Variable ration.

The most advantageous condition for the utilization of the nutritious elements of a forage is realized when one gives to cattle an average ration. Too small a quantity of these elements has the effect of diminishing the accumulated reserve in the organism. In cases of excess they are eliminated and are found in the excrements.

When one has in view the fattening of live stock it is important not to lose sight of the fact that the animals under consideration should first of all be in a condition favorable for the repeated assimilation of albumin and fatty substances and their subsequent deposit in the form of flesh, muscle and fat. It is for this reason that it is desirable under all circumstances that cattle to be subsequently fed upon a ration of any kind should undergo a sort of preliminary diet leading up to the standard ration that they are ultimately to receive. This should, in most cases, continue for a period of weeks before the standard fattening substances are given in which the proportion of nitrogenous to non-nitrogenous elements is superior to that which the actual feeding in view demands. The substances to be given in a fodder should be taken according to their prices upon the local market; but under all circumstances one should make allowance for the composition of the product used, as otherwise the result obtained would not be compatible with the resulting money returns from such feeding. Upon general principles it is recommended that the feeding begin with a smaller quantity of the fodder than one wishes the animal subsequently to eat; this to be in excess of what it has hitherto been accustomed to receive. A too frequent change in the composition of a ration has certainly a very deleterious effect upon animals in general.

Hygienic conditions.

It is above all very important that the hygienic conditions should not be overlooked and that these be adapted to the animals fed. The temperature of the stable should be maintained at 12 to 20 degrees C. (53.6° to 68° F.). It is, furthermore, essential to see that the order of the meals, three at least per diem, shall be the most desirable, as far as the general health of the animal is concerned.

Importance of regular feeding for cows.

Milk, for instance, is not a simple separation from the blood: it is produced at certain stages of the animal's existence and only then. It is the outcome, so to speak, of the dissolution of the udder itself, and it is the function of the forage to repair the losses which the organism undergoes, hence the reason why the consistence of the forage should be appropriate to the work it is to accomplish and why it should be continued with regularity.

Working animals.

Nitrogenous constituents will constantly and repeatedly renew the cells of the udder, which are mainly made up of nitrogenous substances. The albuminoids should consequently combine as soon as possible with the vital fluids in order to be rapidly utilized in the manner just mentioned. For animals destined for work, a nutritious, rich and nitrogenous ration is recommended, to support the losses which the muscles undergo. Alongside of these elements are the fatty substances, which are also very important. Recent investigations demonstrate that muscular work is always accomplished by a considerable consumption of carbohydrates; sugar, for example, can often form a new source of energy for a fatigued organism. It is under all circumstances essential not to overwork animals, as, if they are in any way emaciated through the loss of flesh, it becomes necessary to make up this loss—which always means a drain on the system—by the use of a supplementary amount of forage, by the means of which the original muscular energy may be restored.

Rations for stall-fed animals.

For animals not working, it is proposed that the proportion between the albuminous and the non-albuminous substances shall be as 1 : 10. Working animals and those being fed should receive an additional amount of albuminoids. If working oxen have been called upon for exceptional service in the fall of the year, they should be brought up to a normal standard during the winter, viz: they should be well fed, not necessarily to excess, as the expense would not be justified, and four to six weeks before their spring working commences their nourishment can be increased.

Upon general principles, it may be said that this question of feeding-up should be carried on so that it be palatable and rational, resulting in the maximum effect at the least possible expense, and under all circumstances keeping out all those objectionable elements which would in any way impair the general health of the animal under consideration.

Conclusions.

Now the question is brought within the sphere of a very rational science and may be made very profitable. Fodders may be made as profitable to farmers as the cultivation of cereals; in the latter case, the farmer is always at a disadvantage, for what he extracts he can never return to the soil, and this may also be said of potatoes and many other farm products. Here is one of the special advantages offered by the beet. In all periods of our agricultural history, the farmer has hesitated to grow other than that which has a market value, and feeds are thus neglected; in the beet he combines both—grows something which he sells and which he can subsequently utilize as food. Whatever be the advantage of the fodder, success also depends upon the selection of the animal to be kept, and its age and kind should depend upon the locality where it is to be fed. Distant from towns, ordinary cattle fattening may be the more profitable; near cities, on the other hand, dairying is the most desirable. Before either is commenced, the farmer should know just how much forage he can dispose of, as upon it depends the number of animals to be fed.

Stall feeding, with any idea to profit, in most cases leads to negative results during the winter; if farmers can cover their expenses and have the fertilizer as compensation, they may in most cases consider themselves lucky. The utilization of diffusion pulp may be made very profitable in those cases where all other fodders are too expensive. Farmers frequently decline attempting more than a reasonable future will allow, and at the approach of the cold weather the steers are sold, frequently at a loss, the stalls remain empty and farm hands are dismissed at the very time when the struggle for life is most difficult. The pulp combination in the animal ration not only overcomes all objections as regards high price of staple fodders, but brings about social prosperity among those interested by furnishing labor to the unemployed; it allows a more extended rotation of crops and supplies barnyard manure in abundance. The working population have meat at a lower price, and milk, butter and cheese are sold at regular market rates, regardless of the abundance or scarcity of fodders in general. In cases where farms are within a reasonable proximity to beet-sugar factories, the fertility of the soil is maintained for the reason that the salts extracted during the cultivation of a crop of beets are subsequently returned.

We are convinced that the results obtained in feeding scrub cattle with cossettes, are very misleading in more ways than one. The time will certainly come when a certain selection will be found advantageous, for then will follow better assimilation of the product fed and a higher quality of the resulting meat. Evidently, all facts being equal, the longer the cattle may be kept, the higher will be their price per pound upon the market. This question undergoes important changes, and the present outlook is not encouraging in this direction.

PART FIRST.

Feeding and Fattening Young Steers and Cattle.

Theoretical considerations relative to the formation of fat.

It has already been pointed out that the value of an animal and the facilities for fattening, depend upon the amount of fat already stored up.

Fats in fodders may be reabsorbed and deposited in the body without undergoing any special change; fats that have an entirely different composition from that of the body are not reabsorbed, but must undergo many combinations before being assimilated. It then becomes evident that the fat of fodders is not necessarily stored up at once, notwithstanding that their composition is very much the same as animal fats.

The problem consequently is to determine which are the nutrients that supply the greater part of the fat deposited. The principal groups to be considered are the albuminoids and carbohydrates, as it is mainly from them that the fat is derived.

From the knowledge at our disposal, we conclude that part of the protein of fodders when it does not undergo a fermentation in the intestines may generate fat, which, as a general thing, is burned during the act of respiration at the same time as the digestible fat furnished with the fodder. It is maintained that the only way of explaining the formation of fat in the body from a given food is to consider the fat in the ration, and then what is formed by the splitting up of the protein of the feed. The interesting problem now before us is to determine how domesticated ruminating animals store up fat, and how this can be accomplished to the best advantage, as is necessary in systems of fattening and in meat production. The only solution within our reach is the determining of the efficiency of a ration by the increase of weight after fattening.

Investigators have frequently been too hasty in declaring that carbohydrates were not direct fat formers. In Kühn's experiments it has been shown that only 24 to 64 per cent. of fat furnished in fodder is deposited in the body. In some special cases the accumulation of fat was so rapid that there could be no doubt that it must have had a carbohydrate origin. In the old theories it was admitted that 51.4 parts of the oxidized protein of fodder was converted into fat, and by adding this amount to the fat of fodder it was possible to obtain with considerable approximation the amount of fat formed.

The influence of carbohydrates on the formation of fat has been most carefully examined by Soxhlet, of Bavaria, Tschirwinsky, of Russia, and Weissel, of Austria. Most of these experiments were upon swine, and it was shown that the protein and fat of fodder could account for the fat obtained. In the experiments of Weiske and Schulze upon geese, with a nutritive ratio of 1:5, the influence of carbohydrates could not be doubted. If it is admitted that 73 to 84.8 per cent. of the fat formed comes from the protein and asparagin, 13 to 17.6 per cent. must have been furnished by the carbohydrates. Experiments upon dogs show that carbohydrates are rapidly and completely burned and converted into carbonic acid. While the whole question continues to be based upon theory, experiments made thus far appear to prove that an increase in quantity of the fat of fodder is followed by a slight increase in the animal's weight. Fat coming from the splitting up of protein is more readily converted into animal fat than the fat of fodder, and the rapidity of fat formation is greater in a fat than in a thin animal. Too much water in fodder has a destructive effect upon protein and upon the organic substances of the body; consequently too watery fodders should be used with great caution. The ambient temperature of the stable also has an important influence, as a considerable part of the animal's vital heat is absorbed in heating the air of the lungs up to the temperature of the blood, and if the heat of the stable is too high, evaporation is excessive and the assimilation of food very uncertain. The size of the body is not without importance; small animals demand for their nourishment proportionally more food than large ones. All bodily exercise means a consumption of fat.

A strange habit prevails in some centers which consists in bleeding animals to be fattened; it is maintained that there follows an increase in the absorption of oxygen and elimination of carbonic acid, which, in other words, means a decrease in the decomposition of fat, which is followed by an increased storing up the latter. A fact now generally admitted is that the poorer the blood of an animal, the greater is the amount of fat stored up. The influence of carbohydrates on the production and deposit of fat may be explained by taking into consideration the decrease in the decomposition of the fat of the body. While it is generally admitted that 100 parts fat = 244 starch, Voit's experiments prove that 175 parts of starch are equivalent practically to 100 parts of fat. The fact is, carbohydrates are more rapidly oxidized than is fat; they may indirectly render considerable service in preventing in a measure the oxidation of the fat of the body and that furnished by the protein of the fodder. When fodders do not contain sufficient carbohydrates there must necessarily be a loss of fat of the body to facilitate the oxidation that occurs during respiration. The influence of the carbohydrates upon the fat of the body and that of fodders is limited.

Experiments show that when fat is fed in excess of that necessary for the maintenance of the animal, the surplus is deposited. This fact does not hold good for carbohydrates, for while, up to a certain period, they help to store up fat, later, when in excess, their action ceases. The general laws for the formation or production of flesh and fat appear clearly to show that it is not alone necessary to feed fodder in sufficient quantities for the apparent requisites of life, but it must be given so that there exists an actual proportion between the protein and carbohydrates, an average ratio appearing to be the most suitable. When there is insufficient albumin, then the essential requisite for the rapid production of flesh and fat is lacking. A ration containing an excess of protein on the other hand will stimulate the circulatory albumin and the amount of flesh deposited. If the proportion of carbohydrates is too small, they do not exert their influence in preventing a decomposition of the protein, and as a result the amount of fat stored up is not proportional to that furnished by the fodder. An excess of carbohydrates brings about an unnecessary decomposition of protein and fat. Serious complications may arise, and the droppings under these circumstances contain the portions that have not been assimilated.

Theoretical considerations respecting flesh formation.

Most of the early experiments having in view the production of flesh were made upon dogs. A complete account of same would be beyond the scope of this writing; however, the conclusions arrived at are, in some respects, very much the same as they would have been upon ruminating animals, the assimilation or re-absorption being almost identical in the two cases. Wolff says that experiments show that a dog can eat 15 grams of starch per kilogram of live weight; a milch cow or oxen well fed will extract from fodder about the same amount of carbohydrates per diem and per unit of weight, though the same may be said of protein, but not of fat, which ruminating animals do not digest as readily as carnivora. Let the animal be what it may, it becomes carnivorous when starved, in the sense that it consumes its own flesh. When the ration has been properly combined, the amount of protein decomposed from the body per diem and per kilogram of live weight is 1.8 grams for milch cows, 1.2 for sheep and only 0.75 for a stall-fed ox. When the ration is very rich, these figures are more than doubled, as the case may be. The protein consumed during fasting is by no means a sure basis for determining the amount needed to sustain life in a normal condition of health. The protein needed for such a purpose is several times more than the experiments indicate, for if an animal receives more albumin than it actually requires, an equilibrium is after a reasonable interval established, which, in other words, means that in the urine, etc., there is found eliminated an amount of nitrogen exactly equal to the surplus furnished in the fodder, the rapidity of the establishment of this equilibrium depending upon the amount of protein furnished. The conditions must necessarily vary for each case. As to the pros and cons of feeding too much protein, much might be written. There is ample evidence to show that an excess of albumin is better than a deficiency, as the waste, if there be any, is compensated for. Numerous experiments show that the protein consumption is less in a fat than in a thin animal. If a ration rich in protein is followed by one poor in protein, during the first few days the nitrogen expelled will be much greater than that furnished, and later the equilibrium establishes itself. The importance of salt in feeding farm animals has already been alluded to in these pages; however, it is important, in a general way, to say that salt, when given in reasonable amounts, will increase the decomposition of albumin of the body by stimulating the circulation, and the volume of urine thrown off is also increased. When the volume of water used is decreased and salt continues to be added to the fodder, the urine decreases, perspiration decreases, and the body can then furnish the deficiency of water and expel the salt in excess; consequently it is important, when using considerable salt, to give at the same time plenty of water, as otherwise the animal will soon lose weight. The normal conditions are soon re-established when the animal is allowed to drink water in reasonable amounts. A fact not to be overlooked is that an animal should not be allowed, under these circumstances, to drink at liberty, as the protein consumed would be eliminated in abundance.

In special cases too much fat in fodder will slightly decrease the decomposition of albuminoids, due to the fact that more albumin enters the circulation.

There are methods for economizing the quantity of albumin so as to obtain the maximum meat production. In Stohmann's experiments it was shown that by increasing the digestible elements from 8.9 to 9.7 kilos, while the proportion of digestible albumin and carbohydrates remained constant, the amount of albumin reabsorbed was 32 per cent., while before the change was made it was only 18 per cent. of the total contained in the fodder, under which circumstances, when fattening is the object in view, there is a necessity of forcing consumption.

A certain care is necessary when increasing the amount of protein in a ration, as, if the limit is passed, there may be very little deposited in the tissues and the operation would certainly not be profitable.

By the addition of sugar in the shape of molasses or beet pulp to fodder, there would follow a decrease in protein consumption. As to the advantages of a wide nutritive ratio, there is much to be said. If the limit is passed the fodder will not contain sufficient protein for the requirements to sustain life, and the reserve supply is drawn on with a corresponding loss of weight; furthermore, the fat of a ration is one of the expensive elements, and the amount to be used is a matter of consideration depending upon the market value of feeding stuff. If, upon general principles, it can be admitted that the action of carbohydrates is about the same as fats, one would generally find them the more economical.

Ruminating animals when left to themselves consume large quantities of carbohydrates. If animals are fed simply for maintenance they should be given a proportionately small percentage of protein, but it should be supplied, even though in a minimum quantity, as the cattle cannot live without it, and there can no substitute be found for it.

A wrong impression.

The feeding and fattening of steers with beet residuum cossettes is carried on upon a very extensive scale in several of the Western States, and a few facts relating to the same are mentioned elsewhere in this writing. Such combinations as are there used would hardly be practicable in the Eastern States. In what follows we propose to give only a general outline of the requisites for the practical and theoretical feeding and fattening of young cattle and steers, the outcome of the experience of most of the experiment stations and of the leading American and foreign authorities, combined with some personal observations of the writer. Upon general principles it seems very simple to purchase at the commencement of the winter a lot of semi-starved animals, and to feed them upon rations consisting of beet-sugar factory residuum products combined with other forages. The increase of weight is at first encouraging, but towards the end of the fattening certain difficulties arise. The consideration of the advantage of certain foods over others in combination with either fresh or dried pulp or any molasses combinations would take us beyond the scope of the present writing; the local environment has its influence in this respect, and while certain forages may be found to be very superior for the object in view, they may be too expensive to be practically applied to feeding in special localities where the beet-sugar factory is located. Cornmeal bran, oil meal, etc., may be found in most markets of the country at prices that undergo comparatively slight fluctuations.

Difficulties contended with and experiments.

The passage from liquid to solid food for growing cattle is no easy matter; the conditions are most complicated and experiments in this special direction are very limited. What is consumed before a growing animal is weaned has for its principal object muscle and bone formation and general sustenance of the vital processes. Soxhlet's experiments point to the fact that food produced a greater increase of weight in a given time than would have been possible with mature animals; 1.93 lbs. of dry matter consumed per diem per 100 lbs. live weight, gave an increase of 1.8 lbs. in weight. The calves experimented upon were very young animals, under thirty days old. The average consumption of milk during this experiment was 16.2 lbs. per diem, and analysis of excrement proved that only 0.04 lbs. of dry matter was not assimilated, showing that the milk had been most thoroughly digested. The most natural conditions are to allow the calf as soon as weaned to feed upon young grass in the fields. As soon as cold weather approaches they should be kept in suitably arranged stalls, in pairs, never alone, and there should be ample room for them to move about, as a reasonable amount of exercise is one of the requisites for natural development. When the calf is taken from the field to the barn, green fodder should be furnished as long as possible, and it is in this connection that sugar beets render such excellent service; they may be considered as wet green fodders and may be furnished during an entire winter. The future health and commercial value of a steer always depends upon the winter that follows its birth; this is a fact too frequently overlooked. Fodders for winter feeding are expensive, so that growing cattle hardly get the food they require for a healthy maintenance, and as a result, considerable money is lost during the following spring, which period is too frequently devoted to recuperation from the bad effects of being underfed during several months previous. Hence it is recommended to determine in advance exactly what the supply of fodder is and to limit the number of cattle, having their weight and age under consideration, to meet the requirements of the case, calculating an ample supply per diem. Such calculations may be brought to a very practical basis with siloed residuum, fresh or dried cossettes or with many of the molasses combinations.

Water. The question of water is most important. The amount drunk by steers varies very considerably—it may reach over 30 gallons per diem, or be only 12 gallons. Upon general principles, it should be admitted that with an increase of protein in the ration there will always follow an increase in the quantity of water drank, and another factor not to be overlooked is that there is also a variation due to whether the steers are at freedom or tied up in their stalls.

Daily weighing. We are strongly in favor of daily weighing the steers being fattened, when possible, as one can thus make changes in the general rations and bring about special classifications of the animals being fed. Great variations will be noticed in the same animal; some days, for some unknown reason, there will be a falling off rather than an increase in weight of the animal under observation.

Varied feeds recommended. At the various experiment stations of the United States some special food in each case appears to be recommended for steer feeding. The most interesting among these investigations are those with cotton seed, and it is claimed that it offers special advantages for fattening purposes, superior to most grains. Just in what proportions it could be best combined with beet sugar factory residuums must be determined by practical experiments.

Essentials in fattening. It is not alone sufficient that cattle increase in weight, the meat formed should be of the best quality, and increase of weight must be due to fat accumulation that thoroughly permeates the entire fibre. It would be an easy matter to show the increase in profits in dollars and cents. With every profitable case, the most important of all is to have an animal that has inherited certain characteristics tending towards fat. We consider that the great fault of many farmers is that they do not endeavor to draw a close analogy between the requirements of the animals being fattened and themselves; excitement of any kind should be avoided, and the animal must have perfect quiet; hence we consider it a mistake for the cattle-shed to be too near the factory, as the noise from same has a thinning effect and prevents perfect assimilation.

Requisites for success.

Steer feeding, on a large or extended scale, cannot be made profitable unless there are suitable shelters and comforts at the disposal of the animals. It is not desirable to tie up or confine these animals, as they must take a reasonable amount of exercise, which is always followed by better appetites and an increase in the total weight of the ration eaten. The cattle must have comparatively warm indoor quarters where they may retire when so inclined.

The fattening period should last from three to four months, a good limit being four months, under which circumstances the pulp used remains but a very short time in the silos after the campaign is ended, and what is left over is fed to cattle in general. As the fattening period progresses, the nature and requirements differ; hence it is essential to have the ration compatible with these requirements. During the first period the character of the animal should be studied, his likes and dislikes looked after, and, within a reasonable extent, all future rations should be based upon these observations.

Advantages of sugar beet residuum.

One advantage that pulp and beet molasses feeding offers over the regular modes is that the supply may be kept well up to June, and there is thus no temptation on the part of stockmen to turn cattle out to pasture, for this sudden change in diet does not, as a general thing, prove beneficial. There frequently follows an important falling off in weight. It is better to keep them upon the ration they have had during several months previous, up to the time they leave for the slaughter house.

Requisites for successful fattening.

One of the most important points is to keep in mind that the cattle must be made to eat the greatest possible amount. As previously pointed out, it is possible to force the animals, so as to reach 44 lbs. dry matter per diem with an increase of weight of 4 lbs. a day, for a short period. There is ample authority to show that the feeding should be in periods—the first period has the object of pushing or forcing the ration;

in the second the nutritive ratio should be about 1 to 3.5 or 1 to 4, and as during last period the appetite diminishes, the desirability of having a very digestible ration is evident.

During the first period the standard can be 0.35 lbs. hay, 3.2 lbs. beet, 0.18 lbs. oat hulls and 0.11 colza oil cake, which corresponds to one pound dry matter. If we suppose that the consumption is 25 lbs. dry matter per diem, then the ration would be 80 lbs. beet, 8.7 oat hulls, 2.7 oil cake, total weight 95.9 lbs, varying with the eating capacity of the animals being fed. Instead of beets, diffusion pulp could be used, and other by-products could take the place of oat hulls and oil cake, arranging so that the total dry matter be up to the standard and retain the nutritive ratio at 1.5.

The ration during the second period should differ somewhat from the first, and may be made up as follows for a standard corresponding to 1 lb. dry matter: 0.3 lb. hay, 2.5 lbs. beets, 0.12 lbs. oat hulls, 0.11 colza oil cake, 0.12 chopped oil cake, 0.13 wheat bran. If we suppose the consumption is 20 lbs. dry matter, the total ration would be: 6 lbs. hay, 50 lbs. beets, 2.4 oat hulls, 2.2 colza cake, 2.4 lbs. oil meal and 2.6 lbs. wheat bran. In this case, as in the previous one, such materials as are at the farmer's disposal may be substituted for the several products mentioned. The nutritive ratio is lighter than during first period.

The third period is also interesting. We may use during this time, hay 0.30 lbs., beets 2.00 lbs., oat hulls 0.12 lbs., colza cake 0.13 lbs., barley meal 0.10 lbs., crushed corn 0.20 lbs. —to 1 lb. dry matter.

Great care should be taken during the last period to constantly examine the excrements. The slightest colic would completely destroy all probability of success.

Some French farmers get good results by cooking the fodder during the third period and feeding it warm; the cattle eat this with avidity and in greater quantity than they do the usual fodder.

Success depends upon practical experience.

It is for the stockman to determine what kind of steers and of what age he can best feed to advantage, for both of these considerations are important factors in the financial results to be expected from the undertaking. As the steer advances in age it can no longer lay up fat as it could when younger, and finally a period is reached when a sort of physical equilibrium is established, from which time the weight remains stationary and the fattening would be a money-losing operation. Before this limit is reached the average cost for one pound increase in live weight increases; while for one pound gain during the first two months there would be needed 7 lbs. of food, after six months there would be needed 10 lbs. for the same increase in live weight; but this in beet-pulp feeding is of only secondary importance, as the cost of the product used is so slight that it need not be considered upon a basis of a few pounds more or less in the ration per diem, and under these circumstances the stockman can select his own time for selling. By most modes when this residuum is not a factor, the money cost of the fodder and the results obtained no longer leave the stockman master of the situation. Experiments made some years since by Lawes and Gilbert tend to show that for each pound increase in live weight there are needed about 12.5 lbs. dry substance in the fodder.

Money advantages of beet residuums.

Upon examining the numerous bulletins of the experiment stations, one is led to conclude that the cost of food for 100 lbs. increase in live weight varies from $6.50 to $4. With beet residuum pulp fodder at $2 a ton, this cost can be considerably diminished.

Needs for shipping facilities.

A question that certainly needs important attention is greater facilities for shipping. After a journey of several hundred miles there follows a shrinkage in live weight which is very unnecessary if certain conditions of comfort were offered to the cattle during their transportation.

Preparations for shipping.

As to the best modes of preparing fattened steers before shipping, the authorities do not agree; but upon general principles it may be admitted that the less they drink and the fuller their stomachs are of solid food, the greater are the chances of success; they may drink upon arriving at destination. In some cases for long journeys it is desirable to feed on the road, and for this special case caked molasses combinations would evidently offer advantages.

Salt in steer feeding should be used with certain precautions

—it increases the thirst and considerably augments the flow of urine, which are certainly not desirable conditions. The leading authorities admit that the limit allowed for a ration should be about 60 grams per 100 kilos live weight, this amount to be increased up to 100 grams towards end of fattening. In the foregoing we mention that the steer to be profitably fattened must have certain comforts. Upon this subject Professor Henry says: "Dry, protected yards, with sheds on the windward side, under which the animals may lie down in comfort, are the ideal places for steer feeding. To keep the steer stanchioned or confined to a rope in the stable entails useless labor on the stockman, and prevents proper exercise. Crude as has been much of the open yard feeding in the West, the cattle so fed have really experienced more comfort than had they been confined in the stable, as is common in the East." The growing steers should be fed several times a day at regular intervals—for the older cattle the number of times may be reduced, but it is always important to have regular feeding hours. It is a great mistake, as previously pointed out, to introduce the cossette ration to steers at once; several weeks should elapse before the normal standard is reached, and from that time on great regularity should prevail. As cattle become accustomed to their attendant, the persons employed should, as far as possible, always be the same, but their goings and comings should not be too frequent. In special modes of treatment the rations should be combined with almost mathematical precision, for the cattle eat with avidity that combination to which they are accustomed. Experience shows that it is a great mistake to attempt any temporary methods of stimulating the appetites of the animals fed, for a reaction is sure to follow. A very strong impression prevails among the average farmers, who have not had requisite experience, that steer fattening means sufficient capital at the start to purchase a herd and the facilities for their keeping during the fattening period, which may last six months. The difference in the results obtained by a professional stockman who knows just what attention is needed and when it should be given, and another person attempting the work of steer fattening for the first time, will be most striking. What

Essentials for success.

these requisites are cannot be described in print, but our advice to the farmer is to have in his employ a person who has given the question considerable attention for a term of years. The troughs should always be kept clean, and all food not eaten removed after the regular interval for feeding has elapsed. As regards the droppings, Professor Henry says nothing else gives such an excellent idea of the progress of the fattening. "While they should never be hard, they should be thick enough to 'pile up,' and have that unctious appearance which indicates a healthy action of the liver. There is an odor from the droppings of well fed steers known and quickly recognized by every good feeder. Thin droppings and those with a sour smell indicate something wrong in the feed yard. The conduct of the steer is a further guide in marking the progress of fattening. The manner in which he approaches the feed box; his quiet pose while ruminating, and audible breathing when lying down, showing the lungs cramped by the well-filled pouch; the quiet eye which stands full from the fattening socket; the oily coat—all are points that awaken the interest, admiration and satisfaction of the successful feeder."

Milch Cow Feeding.

General remarks.

There has been a considerable amount of literature published respecting milch cow feeding. If one pursues the same a startling fact is apparent, viz., much remains to be done before the entire question may be brought down to a practical and reliable basis. There are so many elements to be considered, such as the individual characteristics of the animal under observation, and the fluctuation of the market price of the foods used. The main object in view being milk, the cow must receive those elements which would tend to increase this milk flow and yet sustain the animal in the best possible conditions. If this feeding is pushed to an excess, a reaction is sure to follow which will destroy all the possibilities of profitable feeding.

However, it must be admitted, that in the entire field of investigations in feeding cattle, there are but few instances where there is a greater harmony in results than that relating to milk production. Just to what extent certain foods are milk producers, how certain rations are adapted to one breed of cows and not suited to another, etc., are questions, to fully discuss which would demand much space—at present simply the more important facts are to be considered.

Under the best regimen concentrates are combined with roughage. It is doubtful if these mixtures would have been suited to the primitive cow; they are the requisites which are the outcome of the modern and special environment in which the milch cow is now living. The cow in its wild state had only her calf to feed; the demands for surplus milk for dairying purposes have resulted in an abnormal increase of the udder and its secretion, and to meet the demands there is an important need of some additional digestible substances that the roughage alone can not supply.

While it is generally recommended that a cow shall have at its disposal all that she will eat, the practice is a mistake after the cow has reached the maximum flow of milk, as the animal will then tend to fatten, and this will be followed by a reduction in the daily flow of milk.

No animal can adapt itself with better advantage, owing to its special digestive arrangement, to varied feeding than can a milch cow. A fact not to be overlooked is the possibility of its being able to use the roughage, and thus no other nutriment is required. While apparently protein, fat and carbohydrates are not directly needed for milk production, they, nevertheless, play some important mysterious role, as the fact of the cow losing weight when they are directly lacking shows without further argument that they are essential. Carbohydrates certainly play an important role, but they cannot alone make up for the deficiency. Most feeders admit that if a cow will not respond to increased feeding by an increased supply of milk the animal had better be sold.

The question of feeding milch cows is a subject that interests every farmer of the country. If his land belongings consist of but a few acres he generally finds it to his advantage to have a cow furnishing the milk for his family use. The maintenance of the animal under the best economical conditions may be better realized with sugar-factory residuums than is possible with any other single feed he may have at his disposal. The price per ton of fresh residuum cossettes is so small as compared with the advantages to be derived from their use, that it becomes possible to reduce the annual cost of the cow feeding to a minimum. A cow properly looked after should yield over 6,000 pounds of milk per annum, this depending, within reasonable limits, upon the animal's body weight. Light cows give proportionally more milk than heavy ones, and the milk contains more fat in the former than in the latter case. Argue as one may, there are certain unknown factors in the case, and the results obtained in dairying tests are very contradictory. We thoroughly believe in the advantages to be derived from the breed, and admit at the same time the arguments of conformation of the animal independent of breed. A writer in a bulletin of the Ohio experiment station points out that from the time the first calf is born until the seventh year, cows will give increasing quantities of milk for a given weight of fodder; from that time on the secretion of the milk glands apparently diminishes.

Dairying based on maternity of the cow.

Dairying based on maternity of the cow is well explained by Prof. Henry. "Nature's practice of accumulating fat beneath the skin and between the muscular fibres of the animal's body is to store heat and energy-producing material against a time of need. The process at first goes on rapidly, but after a time the system becomes gorged, and a further storage of fat is accomplished only at a high cost for feed consumed. How different with the dairy cow, which eats heartily the food given her, not for the purpose of storing fat to protect herself against a time of possible bodily want, but for the nurture of the young. Food given at night is digested and converted into milk ready for the calf in the morning, the assimilated products disappearing from day to day almost as soon as elaborated, making easy way for more of the same kind from the same source—the appropriation by man of the milk designed by nature for the calf makes possible the great art of dairying—man stimulates the dairy cow by abundant feed and favorable surroundings to produce much more milk than is really needed by the calf were it still the object of her care."

Two sorts of milch cows.

Milch cows may be considered from two points of view, for their milk-furnishing qualities and as a source of revenue for breeding. There are cases where they are not profitable as milk producers, under which circumstances they had better be fattened and sold to the butcher; for example in a city, where the milk is the only object in view, and the high selling price permits elaborate feeding. Under such circumstances the cow is purchased when it has attained its full maturity, that is, after the third calf has been born.

Considerations about milk and milking.

The quantity and composition of milk differ with the cow. Certain cows giving considerable milk after calving will soon run dry, while the reverse would be true for other cows. It is always important to remember that a cow that has been dry for a long time gives more milk after calving; that cows reach their maximum of milk production after the birth of the third calf and then decline, but in some special cases their milk characteristics are retained for a very long time. As a general thing the milk will be more abundant and better if the calf is born during pasturage season. An ample supply of milk depends more than is generally supposed upon the dampness of the locality; near the sea or rivers, etc., are the best localities.

Upon general principles it may be admitted that immediately after calving the milk is the richest in protein and fatty substances; the percentage decreases for one week, and then the quality remains constant.

Milk of young animals not having attained their full growth is more watery than that of older cows properly fed. The fattened condition of the cow has also an important influence, and there is not the slightest doubt that it is a great mistake to allow the general constitution of a cow to run down, as the milk is sure to lose its quality. The time of milking not only has an influence upon the composition, but upon the quality of the milk which varies with the same milking; at first the milk contains less fatty substances than towards the end. For example, the morning milk contains more water and less fat than that of the evening, and three milkings per diem appear to be better than two. Whatever be the ration, it is impossible to change a poor milk into a rich one.

Fat percentage in milk is the true and only basis for its sale. The milk obtained while feeding with sugar-factory residuum frequently contains less fat than that obtained with other products, and the dairyman is in this respect at an apparent disadvantage; all facts being equal, beet-residuum fed cows give a greater volume of milk, so that in the long run the money returns prove greater than they are with less milk and more fat.

Calving cow. A calving cow needs a warm, comfortable stable, and should be freely covered with a blanket when the occasion demands; then follow many precautionary measures which are beyond the scope of the present writing, but suffice it to say that after calving the ration should be so arranged as to bring it up to a maximum pulp feeding, regardless at first of the money returns in butter, etc. After this pushing, compensation will necessarily follow. Experience shows that if these early stages are neglected, do what one may, the difficulty cannot be met. After the maximum milk flow has been reached, the cossette feeding should be diminished in a rational proportion, the outcome of personal observation.

Calf-feeding. The ultimate cow is an object that one must always have in view; if the calf does not receive what it needs for its early development the full-grown cow will necessarily be disappointing. What is much to be regretted is that, just as is the case with many women, considerations for the mother come before those for the progeny. The milk of the mother is better suited to the offspring than any possible combination, or even the nurse who makes up for the neglect. In the average methods of dairying, the butter, etc., considered from a commercial standpoint, are more important than the calf, and then one is surprised that there follows an ultimate decline in the quality of the average stock. Giving the calf skim milk as a main food and then whole milk, etc., may be all very well in theory, but the grain diet when it comes is introduced with greater difficulty. These artificial means are always a mistake. Hence the reason for the very faulty conclusions drawn when attempting beet cossette feeding with animals that have undergone artificial methods and the disregard of the regular rules of nature during the early development.

If the start be made with ample nitrogenous foods having in view muscle development, tending also to facilitate digestion, the excellent effects will be of benefit to the cow later on. If the fat-forming nutriments are pushed to an excess, the subsequent milk forming characteristics will be considerably diminished.

Rations and feeds. Upon general principles it must be understood that the ration should be made up under admitted rules, and if it contains too much coarse fodder there will follow a decrease in the milk flow, just as there would if the feed had been too sparingly or excessively given. As regards narrow and wide rations, the bulk of argument for economical milk production appears to be in favor of narrow rations. We must argue from the standpoint of the various localities and be governed by the price of feeds upon the market. In one part of the United States protein may be cheap and carbohydrates expensive, then in other sections the reverse may be the case, so it is best to have some standard and adhere to it as nearly as possible. The feeds to be combined with fresh, siloed or dried residuum cossettes depend upon the local conditions, under which certain forages are more desirable than others. Experience shows that corn and cob meal give more milk than whole ear corn, so the farmer, when possible, should give preference to the former. There is an evident money saving in using cob meal and corn in preference to whole-ear corn, and the assimilation is greater during its passage through the alimentary canal. The advantages of certain cotton-seed meals as compared with gluten, wheat or corn meal, is a question to examine which in detail would lead us beyond the scope of this present writing, and as the hay added must depend upon the local supply, the farmer cannot be benefited by having an extended amount of information as to the advantages of clover hay over meadow hay, for example.

While a large portion of the fodders is produced on the farm, certain feeds have to be purchased, and their utilization is not always profitable from a money standpoint. If a farm could be self-supporting, the ideal in cattle feeding would be reached, and hence sugar-beet residuum offers a practical solution of this rural problem.

Influence of feeds upon butter and milk. There can be no doubt that fodders have an important influence upon the taste of butter. Just what the cause is has never been satisfactorily settled. The winter butter is generally considered very inferior to that resulting from pasture-fed cows. The facilities for keeping, etc., are all influenced by the fodder used. When the ration is poor in nitrogen or not eaten with relish by the animal, the butter does not appear to have the same consistence as when the appetite is good. It frequently happens that butter has a tallow flavor, and in such cases stearin is actually in greater proportion than the fluid fatty substances. With an inferior fodder, milk is always more watery than it is when the ration has been properly combined. Experiments by Schrodt show that certain oil cakes are beneficial in the production of milk, there being, however, one important requisite, and that is that the rape cake used must not have undergone any alteration, but be perfectly fresh.

Certain feeding stuffs have, without doubt, an important influence upon the flavor of butter. Potatoes, beets, barley, etc., all have their characteristics, and certain flours, rice, etc., improve the quality and taste of butter. The composition of milk varies as the milking period advances.

It is important to mention the influence of inorganic substances on the quality and quantity of milk. The flow of milk is very largely influenced by the percentage of mineral elements, such as phosphoric acid and lime. Henneberg and Stohmann show that for the maintenance of an ox of 1000 lbs. live weight, there is needed 0.05 lb. phosphoric acid, 0.1 lb. lime and 0.2 lb. potassa, and if we admit that the production of milk per diem is 10 quarts per 1000 lbs. live weight, this milk containing 0.04 lb. phosphoric acid, 0.03 lb. lime and 0.035 lb. potassa, by adding these, we see that the daily ration should contain 0.09 phosphoric acid, 0.13 lime and 0.235 potassa. No account need be taken of potassa, as all fodders contain it in abundance. Thirty lbs. of hay of average quality (used for 1000 lbs. live weight), contain 0.122 lb. phosphoric acid, 0.256 lb. lime and 0.390 lb. potassa. Of all the fodders at our disposal, there are only straw chaff, roots, beet pulp and certain cereals which cannot be fed alone and demand the addition of a small percentage of lime, and in some exceptional cases there is a deficiency of phosphoric acid. The addition of common salt is very important, as it limits the waste of sodic salts. The beneficial effects of salt are numerous, among which is the stimulation of the appetite, and it also ameliorates the quality of certain fodders. Wolff recommends that sodic chlorid be used in doses of about 30 to 50 grams per diem and per animal.

One of the arguments advanced by the opponents of fresh cossette feeding was that being very watery, it would result in watery milk; but there is ample authority to show that such is not the case. The whole question of the influence of fodders upon the butter fat has been repeatedly gone over, and at the present time the results taken upon the whole are very contradictory and consequently not reliable.

As for flavors of milk and butter, there can be no doubt that onions, turnips, etc., impart certain characteristics, and that certain grasses affect butter in a more or less noticeable degree; just within what limits the breed of the cows has an influence remains to be determined. As pointed out elsewhere in this writing, certain milk characteristics are often attributed to the feed, while in reality they are the outcome of the action of certain micro-organisms existing in the stable; these are frequently due to neglect of the essentials of cleanliness.

The question of flavor of milk is also an important one, and fodders have an important influence desirable or objectionable; hence one must take into consideration the kind of fodder being used. Grass from very low lands, garlic, etc., should not be fed. Many kinds of oil cakes are decidedly objectionable, as they are difficult to keep and result in a milk of objectionable flavor. Brewers' malt in some cases gives an inferior milk.

Theoretical considerations.

It must be understood that milk is not eliminated from the blood as is urine from the kidneys, or any other assimilation and excretion of the body. This fact is made evident by analysis of the ash of milk, which contains considerable potassa and calcic phosphate, while those fluids that separate from the blood contain considerable sodic chlorid. On the other hand, if milk were simply an excretion indirectly from the blood, it would not, within itself, constitute a complete food, and the newly born could not then find the requisites for their development.

In the elaboration of milk from the colostrum, or the first milk secreted, there takes place little by little, a sort of granulation, and finally the cells fill with fat. These latter constitute the milk globules surrounded by casein; they are suspended in a liquid containing casein, milk sugar, and various salts. Milk, as previously pointed out, is in reality a sort of fatty degeneration of the cells of the milk glands; in other words the nitrogenous elements of which they consist are transformed into milk as soon as the glands enter into activity. Casein does not exist ready formed in the blood, but depends upon the association of certain cells. This explains why the colostrum does not contain it just before the calf is born. Milk sugars appear to be the result of the decomposition of albumin and fat.

Milk has, all facts considered, a very regular composition. Just what effect nervous excitement produces remains an open question. The quantity and quality of milk are determined mainly by the composition and size of the milk glands. A well known fact is that with the same fodder the volume of milk obtained from different cows will vary considerably. Wolff calls attention to the fact that the cows belonging to the mountains will give a richer milk than those of the valleys; that very young cows will give less milk than older ones.

It is impossible, even by careful feeding, to bring about a satisfactory secretion of milk, unless the milk glands are constituted for its formation. In this question the race and individual characteristics play a part. Under these conditions the abnormal development of the udder is not a sure indication in advance of the possibility of an abundant flow of milk. Consequently, while feeding is very important, it is not the most essential requisite, and although it has a considerable influence upon the volume of milk obtained, it has very little upon its composition. Above all, the introduction of considerable protein is important, as upon it the constant renewal of the cells of the milk glands depends, as these cells are not only made up of protein, but are filled with it. Another fact is that albumin appears to increase the percentage of solid matter contained in milk. It is important that the protein reach the milk glands as promptly as possible, hence the albumin must be of the circulatory order.

With the view to accomplishing this, it is important to remember that the proportion of nutrients in the ration be well considered. A too narrow nutritive ratio has a tendency to increase the protein consumption of the body. As a general thing, the nutritive ratio for cows can be narrower than for animals fed for maintenance only.

All facts considered, albumin is essential to milk production. Among other advantages, it facilitates the absorption of water, which has a favorable influence upon the flow of milk, etc. If an excess of protein is fed it will be wasted. Feeding exclusively with hay hardly ever gives the most satisfactory results. In ordinary feeding it is noticed that there is considerable falling off when the percentage of digestible protein of the ration decreases, while the non-nitrogenous elements may be in abundance. From numerous experiments made not many years since, it becomes possible to determine almost exactly the amount of digestible protein needed, which is admitted to be 2.3 lbs. to 3 lbs. per 1,000 lbs. live weight, and that of non-nitrogenous substances 13.5 lbs.; the nutritive ratio consequently is about $\frac{1}{6}$, in which is included 0.3 to 0.6 lbs. of digestible fat, while the total dry matter reaches 24 lbs. to 35 lbs.

The satisfactory production of milk may also be accomplished with a ratio containing less nitrogen, but the experiment to a certain extent is rather risky. Wolff says, if after several months the flow of milk reaches 10 quarts per 1,000 lbs. live weight per diem, and if the milk contains fat and albumin in the proportion which constitutes good milk, it would be a great mistake to feed less than 2.5 lbs. of protein. Apparently an increase in the amount of fat of a ration would, as does protein, bring about a favorable effect upon the flow of milk, more especially in regard to its percentage of fat; but practical experiments in this direction do not show this to be the case. It may, however, be admitted that an increase of fat in a ration will slightly increase the flow of milk, which will contain more fat than the normal milk, but it should be fed with precaution, as otherwise it also would be wasted. Just to what this is to be attributed is an open question. Wolff says that possibly a certain amount of albumin of the fodder is not destroyed and influences the flow of milk. It is important to call attention to a series of investigations in which the animals had suitable amounts of oil cake, etc., added to their ration, so that the daily consumption of fat was about one pound, and the total production of milk remained almost unchanged; furthermore, there followed a slight reduction of fat in the milk, accompanied by a greater dilution, and consequently a decrease in the percentage of solid matter. On the other hand, Kühn's experiments show that it is possible to add one pound of fat and thus secure an increased flow of one pint of milk, while the fat percentage of the latter remained about the same. Experiments upon goats differed somewhat from these, and it is difficult to determine just within what limits conclusions of this kind have a bearing upon cows. Experiments of Weiske show that sheep that had been fed with 0.5 kilos hay, 0.5 kilos barley, and 1 kilo beets, did not yield more milk than with a ration of grass *ad libitum* to which was added 0.5 barley and 0.25 kilos flaxseed meal, but the percentage of fat increased from 5 to 6.4 per cent.

When cows are fed exclusively upon hay, the yield of milk per diem will decrease rapidly, but the percentage of dry matter in the milk will increase.

Essentials for Successful Dairying.

Shelter.

The question of shelter varies in importance to the animal being fed; for steers it never means as much as it does for milch cows. When the temperature in the stable is below 50° F., there is a decline in the milk production, and in view of this question, it is difficult to undertake profitable dairying on a limited capital.

Experience seems to show that for 1000 lbs. live weight, there are needed 1000 cu. ft. of air, and in combination with this, ample ventilation and no draught. It stands to reason that if the air is not pure, the quality of the milk will suffer. Just as light plays an important role in the healthy condition of man so it does with cattle and too much attention cannot be given to all these hygienic questions.

Luxury. If a cow can be surrounded with certain ease and comfort, it will tend to increase her milk flow. In this matter we refer to bedding, stable, warm surroundings, etc., and, even in summer, there should be protection against the sun.

Stables. Stables should be spacious and of a constant temperature not too high. The beds should be sufficient and on a horizontal surface. There does not appear to be any special evil effect from keeping manure in the stable, but care must be taken that a reasonable amount of plaster be added to combine with the liberated ammonia.

Breed and kind of cow. Dairying cannot be profitably undertaken unless due consideration is given to the nature of the cow. In most cases the market value of milk depends upon its percentage of butter fat, and certain breeds give more than others and are never the cheapest when purchased but by careful feeding they may be more profitable in the long run. The best breeds do not eat more than the inferior kind, and yet the butter production may be four times greater in one case than in another.

Cows should have a trial. Cows should have a trial even if highly recommended, and if not found up to expectation should be got rid of. A pulp ration may be suited to one breed of special characteristics and not to another. The question can be reduced to a science, and the ultimate result which in no country has ever been sufficiently considered, is to create, as it were, a special cow suited above all others to the diet offered by thorough cossette feeding. A few cents more or less in the selling price of the resulting butter, milk, etc., makes these arguments more and more plausible.

Continued attention. Neglect can never be made up for, and if one cannot give to a milch cow constant and continued attention, there will be a loss in the long run. If the flow of milk for one reason or another decreases, the average is below the normal during the season.

Kindness. The importance of kindness is too frequently overlooked in the care of milch cows, and as the secretion of the milk gland reaches its maximum during milking, it is then that precautionary measures should be taken, for any unkind treatment would simply lower the flow of milk from the gland. Even before or after milking brutality always means nervous excitement with a reducing action on the milk gland flow. Thus the milker has an influence upon the volume of milk obtained, and its percentage of butter, fat, etc.

Feeding.

Time of feeding.

While fodders are essential for the production of an abundant supply of milk, regularity in feeding has an importance equally great. This must never be overlooked, as when the hour comes the cow frets, bringing about nervous excitement, which is always followed by a decreased flow of milk. It is better to feed the milch cow just after milking rather than before, and under no circumstances during milking, as the milk might be contaminated by certain volatile substances that feeds frequently contain. These find their way almost immediately to the milk, which would result also in poor butter. Three meals a day, in which the total ration is proportionally fed, should be given, and if hay is given but once a day, better feed at mid-day. After the last meal straw might be advantageously used. It is important that the animal completely finish one meal before it commences the second.

Successful cossette feeding.

Successful cossette feeding depends in more ways than one upon the feeder; he must care for and be interested in his work, must love animals in general, realize that animals, like men, have certain characteristics and must be dealt with accordingly. The element of cleanliness appears to have been overlooked in certain farms that have attempted cossette feeding, yet success, especially with milch cows, depends upon this; and to attempt looking after many more than twenty cows is in more ways than one a mistake.

Excessive feeding.

Various theories are advanced respecting the influence of excessive feeding, some claiming that its effects are only temporary and that a reaction will soon follow. Experience seems to show that when the ration for milch cows is rich in protein and comparatively poor in carbohydrates, the conditions continue to improve for a long time, while if the carbohydrates are in excess the reverse will be the case.

Difficulties in feeding.

Scientific feeding means that the animal fed receives exactly what it requires, neither more nor less, and this fact alone makes it evident how complicated the whole question of proper feeding becomes. It necessarily means repeated weighing and analysis of feeds used. If these essentials are neglected and merely an average is taken, practical results may be obtained, but it remains to be proved that they are always profitable in the long run.

Stable feeding and exercise. All facts considered, it is possibly best during very warm weather, that cows be taken to the fields during the day and put in the stables at night. The yield of milk is evidently influenced by exercise taken, so if that is the sole object in view, as is the case in proximity to cities, the less exercise the better; if, on the other hand, the object aimed at is to secure a good cow to be subsequently used for breeding, fresh air is necessary. Considerable might be said as to methods of keeping fields in proper condition.

Feeding with the view to butter production. An impression generally prevails that there is a certain relation between the ambient temperature and the hardness of butter, but the truth is, it is the winter ration that is responsible. Let a breeder feed linseed, etc., to an excess and the butter will soften, regardless of the ambient temperature. The same may be said of bran, but the reverse is the case with corn. As hard butter always means more money, the question remains whether it is not profitable in the end to purchase those feeding stuffs that will lead to this result—as the market demands vary so should the ration.

Feeding according to records. Feeding according to records means a constant all-day watching; suitable tables should be made giving the practical results obtained.

Summer feeding. There is a tendency to give up pulp feeding as soon as the grass appears; this change of diet must always be made gradually and with certain precautions.

Question of labor. The question of labor on most American farms is one that neutralizes in a very important manner all arguments as regards the economical production of meat, milk, butter, etc.; that is why the tendency is more and more to adopt a sort of loose feeding, giving ample room for circulation, with abundance of water. The cleaning need only be done at regular intervals of several months. Also it is pointed out that in stall-feeding, the milk is much freer from microbes than when the cows have their freedom; hence what is gained in freedom as regards labor is lost in the quality of the resulting milk.

Bacteria.

Too much importance cannot be given to the question of possible bacterial contamination, and the only way to master its pernicious effects is by cleanliness. The more closely the cow can be looked after, the less are the chances of bacterial contamination. Cleanliness is more efficiently attained in stall than in pen feeding.

Water in feeding.

Whatever be the kind of food used, it always contains water in varied proportions; in grains and dried fodders it may be 8 to 16 per cent., in roots it is frequently 90 per cent., while in green and siloed fodders it is on an average nearly 80 per cent. As water when combined with foods plays the same role as it does when drunk, it does not enter into consideration when the computations of rations are made; for this reason the analysis of fodder frequently expresses water-free or dry matter. The water estimation for fodders in general is extremely simple; it consists in chopping up the sample and weighing; it is then dried at 212° F. for four or five hours, and is weighed several times during this interval; when there is no further variation in weight, the desiccation is complete. The weighing before and after drying gives the moisture percentage.

Water forms an important proportion of an animal's body, and varies considerably. With a well fattened ox it may reach 46 per cent., while in case of sheep, for example, it is not much more than 35 lbs. per 100 lbs. live weight.

Influence of water upon food consumption.

Cattle in general need water, and consequently they eat, with avidity, fodders containing considerable moisture, such as distillers' water and fresh residuum beet cossettes; but there is a limit which never should be exceeded, as many complications are to be feared. Cattle in general eat according to their appetites, and they frequently absorb more water than their healthy digestion demands, and under these circumstances there would be very little flesh or fat formed. It is to be noted, however, that cattle fed on brewers' residuum frequently have a bloated appearance, and when sold upon the market, bring very low prices.

Cattle kept in very warm stables have abnormal thirst and perspire proportionally, which has a thinning effect; and too low a temperature in the stable is also objectionable, as an extra amount of food is necessary to supply the caloric needed to heat the air breathed to the temperature of the body.

The water absorbed has an important influence on protein consumption. Experiments have shown that this increase may in some cases reach nearly 6 per cent. Voit points out that it is a mistake to allow too much water to be drunk when live stock is being fattened, and therefore the salt ration should be limited. It has also been pointed out that the proportion of dry matter in a food to water should be for cattle one to four, and for sheep one-half this. There is ample authority on the other hand to show that in cows allowed to drink at will, the milk flow was increased and the fat percentage remained normal. Many other experiments have been made, however, which tend to show that it is very doubtful if there are any advantages in having water at the constant disposal of cattle, as cows allowed to drink in the yard are as healthy as those depending upon their barn supply.

As the daily milking means drawing off of water, this must be supplied, and some experts declare that one had better allow the cattle to drink twice, once in the morning and once in the evening, rather than only once. Which is the best mode of keeping the water remains an open question. If the stock is being fattened it is better to have the supply in the stable rather than compel the animals to make long tramps to drink at some distant stream.

Water drunk and its influence.

Some experiments have been made to determine the amount of water drunk by lambs during fattening, and the results show that it varied with the food. For sugar beets it was 0.4 lbs., while with oil meal it reached 4.8 lbs. The temperature of the water has an important influence on the flow of milk. Experiments in this direction made at the Wisconsin station with two lots of cows, showed that when the water was at 70° F. on the one hand and 32° F. on the other, in the first experiment the warm water gave 6 per cent. more milk than did the cold water; in the second experiment this difference was very much less. An interesting fact furthermore was revealed, viz., that with warm water the daily consumption was 8 to 10 lbs. more than with cold water.

The percentage of water decreases in an animal as the process of fattening advances, and whatever be the increase in weight, water will represent at least ⅓ or ¼ of the flesh added.

The water when given in excess dilutes the gastric juice and sooner or later brings about digestive complications, and has an important influence on the quality of the milk. The supply of water is consequently a most important question, and under all circumstances must depend upon the ambient temperature. Experience seems to show that, under normal conditions, if the stable be at 60° F., when animals are stall-fed with a ration containing ⅐ of their weight in water, this quantity is sufficient for their maintenance, in fact, they refuse any additional drink. When water is in excess, it stimulates the excretion of urine.

The loss of water through the urine, lungs, etc., is at least 50 lbs. per diem, so that quantity must be furnished, and if, for example, the dry fodders contain 10 lbs. of water, then 40 lbs. must be given as drink.

When excessively diluted rations are given, diarrhœa is sure to set in, hence such fodders are objectionable. This might be an argument against the general use of diffusion pulps, but the difficulty in this case is overcome by a liberal use of chopped straw. So arrange that the requisite amount is furnished, say 3 to 4 times the weight of dry matter in a ration.

Essentials of good water.

Good water should be free from organic matter in a state of putrefaction, and it should be clear. Water under all circumstances must have combined with it a certain amount of air, otherwise it would be heavy on the stomach. River water appears to offer certain excellent conditions, and rain water may also be used. Water in swamps, from drains, etc., need only be considered bad when it has a strong characteristic odor and in most cases animals prefer it, even when strongly charged with urine, to any fresh from a fountain. Some authorities recommend that bran or wheat flour be added to water with the view of purifying it.

Salt.

Salt should be at the cow's disposal, and it is a mistake to give only rock salt. A great mistake is also an over-feeding of salt, the outcome of a faulty practice of mixing this with the ration. When cows have for a time had less salt than they actually need, it should not be introduced suddenly into their ration.

Mistake in starting a dairy.

To produce an inferior article, as has been frequently done through the temptations of cheap feed, means no profitable future; hence certain preliminary tests should be made, for competition always exists and the investment may prove a failure, not on account of the inferiority of the product fed, but due solely to neglect of the most elementary principles of cow feeding. With poor stock upon the start, there necessarily follow discouraging results.

If the animals are not to be stall-fed it is important, before attempting to start a dairy, to take into consideration the pasturage facilities in the vicinity, and while in the foregoing damp soils were, to a reasonable extent, recommended, it must not be forgotten that stagnant water is very objectionable, as the milk would certainly be influenced thereby.

Cooperative methods.

In the West the distances are comparatively greater than in the East; there, as elsewhere, the attempt at cossette utilization on a cooperative basis, if there are not at least 600 cows to form part of the combination at a distance of a few miles, will, upon general principles, never prove a success; under no circumstances should this be done in an amateur way, but the advice of recognized experts, and not of agents representing specialists, should be taken.

Calculation of Rations for Milch Cows.

Preliminary Remarks.

While in this country most of the directors of our agricultural experiment stations accept the European standards and methods for the calculation of a ration for milch cows, etc., very satisfactory results are obtained by the so-called empirical systems of feeding. Farmers are too proud to admit that they cannot manage their own dairying establishments without the aid of scientific theories and a ration is compounded by them which yields a given number of quarts of milk per year with considerable profit to all interested. They forget that the very proportion of which their ration consists has not been determined by them as they imagine, but in reality approaches in some form or another a standard that was the outcome of theoretical consideration. Let the fodder be changed, and the practical man will then be only too glad to consult with an agronomist to know just how much coarse by-fodder is to be fed to meet the requirements of his special case. It is not alone sufficient to get together fodders that will give satisfactory yields of milk and butter, but these results must be accomplished in the most economical way. It may often be cheaper to purchase certain fodders than to use in excess what happens to be on hand at the period of feeding, the cost of which rations may vary from 10 cents to 35 cents per diem. It may be more profitable to spend 25 cents upon a cow's ration, than it is to save 15 cents by using fodders not suited to the special case under consideration. While in most calculations very little account is taken of the manurial value of the droppings, these in reality, if properly collected, will represent nearly one-half of the original cost of the ration, which in dollars and cents means, that if this manure had been purchased, it would be worth in itself one-half, and frequently one-third, of the original cost of the feeding stuffs used. For many districts this value of manure has but a secondary importance, at least for the present, and it is unnecessary to take it into consideration.

While the principal authorities, such as Kühn and Wolff, differ as to standard rations, there is not so much variance in their theories as would at first appear. They each admit that a certain number of pounds of organic matter, protein, etc., must be fed. The Wolff rules are not so elastic as those of Kühn; but practical experiments have shown that they both have advantages and disadvantages, and neither of them takes into consideration the individual characteristics of the animal being fed. While the Wolff tables have been more generally adopted than those of Kühn, practical experiments of the dairying associations of the United States show that the standard rations used and determined from long experience, are in reality nearer those of Kühn than Wolff.

One hundred rations for milch cows.

The University of Wisconsin has collected one hundred rations of dairy cows in the different parts of the country.* A synopsis of these rations arranged according to States is shown herewith. When they are compared with the Wisconsin standard, they are found in some way to be faulty in their combinations. Corn silage and wheat bran are the most popular fodders used. These are followed by mixed hay, corn meal and linseed meal.

The nutritive ratios, with the exception of those of the Rocky Mountains and the Pacific States, are very nearly what they should be.

COMPOSITION OF ONE HUNDRED RATIONS FOR DAIRY COWS.

	Dry matter.	DIGESTIBLE MATTER.				Nutr. Ratio.
		Protein.	Carb. hydr.	Fat.	Total.	
New England States	24.28	2.10	13.19	.75	16.04	1:7.1
Middle States	24.65	2.27	13.68	.82	16.77	1:6.8
Central States	22.97	1.97	12.78	.72	15.47	1:7.3
North Central States	25.79	2.08	13.79	.68	16.55	1:7.3
Southern States	23.48	2.00	12.14	1.05	15.19	1:7.2
Rocky Mountain States	30.81	3.12	15.39	.79	19.30	1:5.5
Pacific States	21.60	2.68	10.54	.55	13.77	1:4.4
Canada	21.57	1.76	11.69	.63	14.08	1:7.4

Requirements of American cows as compared with European.

The average annual yield of milk and butter for the 2,921 cows fed on the above rations was 6,314 lbs. and 303 lbs. per head respectively; the general average of fat in herd milk was 4.59 per cent. After a careful study of the question, we must admit that our cows need more fat and carbohydrates than the European standards call for. This may be readily understood by reason of the severity of our climate, which demands more heat-forming elements to maintain the caloric of the body. In most of the dairying centers of the Eastern and Western States, snow is on the ground several months of the year, and the requisites, under these circumstances, must differ as regards winter feeding from those at centers where most of the experiments upon the digestibility of feeding stuffs have been made, in fact where the nucleus of the entire science originated. It must be constantly borne in mind that the standard we have adopted is simply a guiding basis for scientific feeding. It is for the farmer to determine within what limits the individual characteristics of a special environment are suited to the cow being fed. It is important, however, not to be too hasty in drawing conclusions, as a reasonable number of days must elapse before the animal under consideration can come under the entire influence of its new ration.

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*See Bulletin No. 38.

The standard adopted.

By the use of special tables for computing rations* for farm animals, the work is much simplified. Many of the detailed calculations are done away with, and only the results are given; hence by their use there is a considerable saving of time.

Special tables.

In calculating a ration, the main object in view is to combine several feeding stuffs so that their total dry and digestible matter shall be near a standard accepted as a basis. To attain the result in view, one must make a number of trials, reaching the desired conditions only after several substitutions and alterations. Many of the rations used for cattle feeding are by no means standard, and will not bear examination. For example, on many dairying farms in California, 100 lbs. of residuum cossettes, 15 lbs. hay and 5 lbs. barley per 1,000 lbs. live weight are used. This ration has the following percentage of dry and digestible matter :

Faulty rations.

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* The tables used are to be found in Part Six of this volume.

Composition of Ration No. 1, Fed to California Dairy Cows.

	Dry matter.	Protein.	Digestible carbohydrates and fat.	Total.	Nutritive ratio.
100 lbs. residuum cossettes	20.8 lbs.	0.6 lbs.	7.3 lbs.	7.9 lbs.	1:12
15 lbs. hay (clover)	12.95 "	1.02 "	5.94 "	6.96 "	1:5.8
5 lbs. barley	4.45 "	0.43 "	3.46 "	3.89 "	1:7.9
Total	38.00 lbs.	2.05 lbs.	16.70 lbs.	18.75 lbs.	1:8
Wisconsin standard	24.5 "	2.2 "	14.9 "	17.1 "	1:6.8

While the total digestible matter is in excess of the Wisconsin standard, the total dry matter is out of rational proportion, and the ration taken as a whole is too wide.

Another example taken from the same State is of interest. A dairyman writes us that he gives to his cows a daily ration consisting of 80 lbs. fresh or siloed cossettes, 6 lbs. corn and cob meal, and 6 lbs. hay.

Composition of Ration No. 2, Fed to California Dairy Cows.

	Dry matter.	Protein.	Carbohydrates and fat.	Total.	Nutritive ratio.
89 lbs. cossettes	8.0 lbs.	0.48 lbs.	5.84 lbs.	6.32 lbs.	1:12
6 lbs. corn and cob meal	5.1 "	0.264 "	3.99 "	4.254 "	1:15
6 lbs. hay	5.10 "	0.408 "	2.36 "	2.768 "	1:5.8
Total	18.2 lbs.	1.152 lbs.	12.19 lbs.	13.342 lbs.	1:10

This ration is certainly not to be recommended, as not a single portion of it is up to the desired standard, yet it appears to be in practical use.

Manner of calculating a ration.

We shall now give a general idea of how a farmer may calculate a ration. No technical skill is required, only very careful handling of the data contained in the tables previously referred to.

In the present example, we may suppose that a farmer has 50 cows of an average weight of 1000 lbs., and that all conditions are favorable for cattle feeding; also that the winter feeding lasts from November to May, we may say 200 days, and that the barn contains 40,000 lbs. clover hay and 70,000 lbs. oat straw. Residuum cossettes have been obtained at the beet-sugar factory and siloed, the quantity being 200 tons or 440,000 lbs. As 70 tons of beets offered to the factory have been refused, they must also be kept during the winter, and represent 154,000 lbs. Under the best circumstances, it is not desirable to consume all the hay on hand, but for the present we may simply suppose that it is all fed, other fodders being put aside for spring feeding. The 40,000 lbs. clover hay to be consumed in 200 days means 200 lbs. per diem or 4 lbs. per cow. In the same manner the consumption of oat straw should be 7 lbs. per diem, 44 lbs. cossettes, and 15 lbs. of beets.

If we should use only what is on hand, the daily ration for each cow would be as follows:

COMPOSITION OF SUPPOSITIOUS RATION FOR DAIRY COWS.

	Dry matter.	Digestible.			Ratio.
		Protein.	Carbohydrates and fats × 2.25.	Total.	
4 lbs. clover hay	3.40 lbs.	0.272 lbs.	1.584 lbs.	1.856 lbs.	
7 lbs. oat straw	6.37 "	0.084 "	2.828 "	2.912 "	
44 lbs. cossettes	4.40 "	0.264 "	3.212 "	3.476 "	
15 lbs. beets	1.95 "	0.165 "	1.560 "	1.725 "	
Total	16.12 lbs.	0.785 lbs.	9.184 lbs.	9.969 lbs.	1:11
Standard	24.5 "	2.2 "	14.9 "	17.1 "	1:6.8
Difference	8.38 lbs.	1.415 lbs.	5.716 lbs.	7.131 lbs.	

The fodders to be added must make up for this deficiency, and the kind, depend upon the market price and the locality in which the farm is situated. It must be noticed that the ration as it exists is entirely too wide, hence there should be added a fodder with narrow ratio. The tables show that 9 lbs. of wheat middlings will very nearly furnish what is needed, and as they may be had at a low price they may be used.

MODIFICATION OF ABOVE RATION.

	Dry matter.	Protein.	Carbohydrates and fat.	Total.	
Previous ration	16.12 lbs.	0.785 lbs.	9.184 lbs.	9.969 lbs.	
9 lbs. wheat middlings....	7.92 "	1.152 "	5.463 "	6.615 "	1:4.7
Total	24.04 "	1.937 "	14.647 "	16.584 "	1;7.5

The ratio is still rather wide, and there remains 0.27 lbs. protein to be furnished. We must select a fodder that will have a low nutritive ratio, and one pound of linseed meal meets the essentials:

FURTHER MODIFICATION OF ABOVE RATION.

	Dry matter.	Protein.	Carbohydrates and fat.	Total.	
Previous ration	24.04 lbs.	1.937 lbs.	14.647 lbs.	16.584 lbs.	
1 lb. linseed meal	.90 "	0.282 "	0.464 "	0.746 "	1:1.6
Total	24.94 "	2.219 "	15.111 "	17.330 "	1:6.8

Without the use of well arranged tables considerable guess work must be restored to, but by their use the problem is solved almost at a glance. In the calculations one could enter into great detail as to the cost of the ration per diem. With pressed cossettes from the factory a very important portion of the nutrients is obtained at a comparatively low figure. In the case we have supposed, the 450 lbs. of wheat middlings and 50 lbs. of linseed meal per diem would have to be purchased, and should be on hand as soon as possible. It means the purchase of 450 × 200 or 90,000 lbs. with 10,000 lbs. linseed meal, the latter costing not more than $20 a ton and the former $18 per ton. The money outlay for the farmer is certainly less than $1,000, from which he has 10,000 rations, meaning 10 cents per ration. As the cossettes are had free or at a cost of 50 cents per ton, they enter into the ration for less than one cent. As the beets cost the farmer at least $3.00 a ton, they enter the ration for less than two cents. All facts considered, the daily ration consisting of 4 lbs. clover hay, 7 lbs. oat straw, 44 lbs. sugar-beet cossettes and 15 lbs. of beets should cost less than 13 to 14 cents per diem.

The feeding of steers, lambs, etc., offers no difficulty; if their rations consist of dried or siloed cossettes, or even of the various molasses or sugar fodders, the calculation is done in exactly the same manner. The standard ration for each animal differs. The question of economy in the use of the by-fodder added must be separately calculated, and would take us beyond the limits of the present writing.

Sheep Feeding.

General considerations.

The beet pulp utilization has given an enormous impulse to sheep raising in the United States. No less than three instances may be cited in which the lots are 30,000 each, hence the importance of having a general outline of the requirements for the successful care-taking of these animals at various periods of their growth. As the milk of ewes is seldom used for man in this country, its characteristics need not be discussed for the present. Several of our experimental stations have taken up the question of comparing the results obtained in lamb feeding with cows' milk and with regular rations made up of various feeding stuffs, and decided in favor of the milk. As milch cows are usually fed in large number with residuum beet cossettes, the milk required for the special purpose of lamb fattening at certain seasons of the year, generally in mid-winter, may be had at a very low cost, and almost defies all other competition.

During the very early days of the lamb's existence it had better depend upon its mother for its subsistence, and the importance of having the ewes well looked after is self evident. A suitable diet is needed, and express orders should be given not to permit shearing, as experiments show that this is generally followed by a decrease in the flow of milk. However, when from local reasons there is a marked demand for the wool, the secreting powers of the ewes may be restored after a week's time by the judicious introduction of certain feeding stuffs in the ration.

The age of the animal has an important influence on the possible money profits that are to be derived from fattening, the young animals being, in the long run, more profitable.

In whatever State sheep feeding with residuum pulp is practiced, one is to a certain extent dependent upon the breeds that the locality can furnish. Certain breeds are more profitable than others. For breeders who purpose to continue with lambs from year to year, it may be considered advantageous to carry out certain comparative breed tests. In order to save money and time, experiments have been made with self-feeding appliances, the grain being placed in a special upper receptacle, and falling by gravity as the hopper connecting it with the trough becomes empty. The sheep have in this manner food *ad libitum.* These devices have never been up to expectations, and are not to be recommended.

Mistake of shearing during feeding.

We have already mentioned in a general way how the shearing influences the milk; in the same way the possibilities of fattening are lowest when the wool has been removed. In this respect the experiments of Craig of the Wisconsin station have brought to light some important conclusions, among which may be mentioned that shorn lambs eat more, drink less water and make 30 per cent. less gain than the unshorn, hence when fattening is the object in view the shearing, and even increase of wool, is objectionable.

By shearing in the fall of the year and again in the spring more wool is obtained than from a single spring shearing, but the market value of the two clippings is not any greater than of the single clipping, in which the fibres of the fleece are larger. When the lambs are to be fattened during three or four winter months, there appears to be no practical advantage in fall shearing. A rather surprising result obtained in this question of sheep fattening is, that unlike the steer, very little advantage is to be gained by in-door feeding. Evidently to make up for the difference of temperature in the two cases, more food is required to obtain the same results. Whatever be the success in feeding, there will always follow a certain shrinkage when sent to their destination, and the question is open to discussion whether in the long run it would not be more profitable to have the stock yards in the direct vicinity, especially as the resulting blood could be combined with the molasses and cossettes to form part of the regular daily rations.

Beet cossettes and the wool.

There is very little available information as regards the exact advantage of introducing beet cossettes on an extended scale in sheep feeding, but the results in Nebraska show in a general way that the advantages are considerable. Just whether it is advantageous to use corn, wheat, etc., depends upon the locality in which the feeding is done, and when the beet cossette feeding has become very general in its applications, we are convinced it will completely change all existing modes, resulting in greater economy and facility. Certain facts always remain, whatever be the mode of feeding. A long series of investigations will be needed to determine exactly what influence cossettes have on the quality of the wool; however, in this respect, as every one knows, the environment has more influence than the actual food eaten.

Sheep characteristics.

Among all the animals the breeder has to handle, none can subsist on more varied rations than can sheep; they evidently adapt themselves to any circumstances that may arise. The general characteristic of the sheep is that its general condition improves when in flocks of several thousands. When these extensive flocks existed some years since, it always necessitated a large area of ground in some corn State, and the experienced

Requisite feeding space and other essentials.

care of a shepherd. Now with an abundant supply of residuum beet cossettes, special quarters are provided which occupy a comparatively limited space. Professor Henry* discussing this question says: "A ewe weighing 100 lbs. will require about ten square feet of ground space, while one weighing 150 lbs. should have 15 square feet. A space 40x40 feet square will therefore accommodate about 160 sheep weighing 100 pounds each, or 100 weighing 160 pounds, not allowing for feed racks. Provide 15 inches running length of feed rack for each sheep weighing 100 pounds, and two feet for those weighing 200 pounds." "Sheep to be profitable must be kept dry as to coat and feet; inattention to either of these essentials will result disastrously. . . . One thickness of closely-matched boards will make the barn or shed where sheep are confined sufficiently warm in the Northern States, except for winter lambs."

In several efforts at sheep feeding in the United States, coming under our notice, the flocks are simply collected together regardless of their weight, size and general characteristics, and the ultimate results obtained would certainly be disappointing if critically examined.

An enormous number of lambs die after being born; the early care needed is frequently lacking, as the object in view is simply fattening; but this will change in time and the requisite hourly care-taking will be given. The American sheep and lamb cossette feeding is generally over before the time for pasturing has arrived, and even if this were not so, the pasturage in most cases where factories are located would not be sufficient to meet the requirements of the case. However, in this respect there is much to be said, for in cases where the cossettes have been properly siloed the feeding can continue well on into the spring, the flock being removed when the desired fattening limit has been reached,† and it is then recommended to allow the lambs to have the full run of the fields, returning to their mothers through smaller spaces than the ewe can pass. As the lambs may be born at any period, it is well to adopt the system of placing something tempting for the lambs. As regards the quantity of water to be allowed sheep, authorities differ, some declaring the less water the better, some that a few quarts daily are sufficient. Too little attention has hitherto been given to the feeding troughs, which should be constantly cleansed, and the cossette ration not eaten removed and replaced by fresh.

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* See "Feeds and Feeding," p. 516.

† The increase according to the best authorities is one pound live weight per 10 lbs. dry substance fed.

Importance of sheep selection.

In the general rush at sheep feeding on an extended scale with the view to utilizing cossette fresh from the factory, too little attention is given to medical examination of the animals to be fed, and the result is that disease soon spreads and plays havoc among the flock.

Sheep fattening.

Just as is the case with milch cows, sheep must be fed at regular intervals and treated with constant kindness; they become accustomed to special attendants, and they alone had better handle the question of feeding. In whatever State the sheep feeding is carried on, there are always certain essentials for the market; but just what these are would carry us beyond the scope of the present writing. The fattening proper cannot commence until sheep have been not only weaned, but have got their full set of teeth.

In countries presenting passable conditions the sheep grazing can commence when the cattle leave off. It is important that the sheep be not allowed to walk distances out of proportion to the food gathered, otherwise the exercise would not lead to very beneficial results as far as the farmer is concerned. Evidently the best meat is obtained from sheep that are familiar with good pasturage on lands more or less charged with salts, like those near the seashore, which frequently offer the best results.

The fattening of sheep is a much more difficult process than that of cattle, owing to the individual characteristics of each. They must be classified not only according to weight, but also in regard to special characteristics. The rule is to give stimulating food, so as to obtain the greatest possible consumption per diem.

When rams have commenced to give evidence of their maturity they require a very different ration from sheep that have been altered or females.

The varying requisites in sheep raising render their profitable breeding most difficult. It is pointed out that when conditions permit, that sheep, even in summer, be not allowed to leave the fold on empty stomachs. The change from dry fodder to pasturage should not be accomplished too rapidly. A good custom that seems to prevail is that of giving sheep plenty of exercise even in cold weather. The principal difference in fodders to be given to older sheep and types, previously mentioned, is that the percentage of coarser feeds is to be augmented and the concentrated diminished. The total per diem is diminished and carbohydrates increased.

While oats are objectionable as a general ration, in this special case they render excellent service; as they have an exciting tendency on the procreating organs, their introduction as a ration must be effected gradually, just to take the place of bran; and when the greatest effect has been produced the ration is withdrawn little by little. In all casss the question of age is an important factor.

Raisers of sheep have many theories that are not altogether in accordance with practice. Ample feeding for sheep is as important as it is for cattle.

Unlike cattle, there is no special time for sheep to be born, and it occurs just as frequently in summer as in winter. The rations during the two periods must, however, differ; in summer there is the natural pasturage, and what sheep can utilize is very different from that for cows. The question remains to be solved just within what limits lands are suited to sheep. Swampy low lands do not give satisfactory results. The lands should not be too far from the fold and farm to furnish sufficient food to thoroughly satisfy their appetites almost twice a day. It has been suggested that the best method for determining the quantity of grass, etc., needed, is to weigh a certain number of sheep before and after their feeding, by which means one could ascertain the average consumption. When winter feeding is considered it must not be forgotten that sheep during gestation have not attained their full growth, and should be fed accordingly. Very coarse fodders are not suitable for sheep; too highly fermented food is also objectionable; excitable fodders are very objectionable, and the nutritive ratio should be 1:4, with at least 60 per cent. moisture. Beets give excellent results, and should in all cases be mixed with chopped straw, etc. It is difficult to determine the exact quantity of fodder to be given; the best guide with sheep is the amount they refuse.

Great advantages are to be derived by allowing sheep to have all the milk from the mother that they need. The health of a sucking lamb depends upon the health of the mother. The discussions of this question are outside the province of the present writing.

One sheep should never be allowed to feed more than one lamb at a time, and in special cases the use of a bottle may give excellent results; two quarts of milk per diem is readily consumed by an average healthy lamb.

Good and well selected fodder comes next in importance. Great care should be taken that the fodders be not too rich and dry. The lamb as well as the mother under such rations would soon die.

During very rainy weather the grass and general pasturage contain so much water that it is frequently found possible to supplement their food in fold. The sucking should be repeated four times a day (at first much oftener), and during the interval the mother has ample time to recuperate. Arrange so that the mother and young one are separated by a partition with doors large enough for the lamb to pass, but not the mother. The first tooth appears after four months, and the weaning should then begin. One meal of oil cake, etc., is furnished during the interval of their sucking. These meals become more numerous, and within a month the weaning should be complete.

It may be considered a mistake to make a distinction between the requirements of male, female or altered sheep. The object in all cases is the same, that of securing in one year the most complete development possible.

The French authorities are strongly opposed to the use of oats in sheep rations, as this fodder has a very exciting tendency and as a result a very thinning effect. The summer pasturage is very much the same as it is with sheep. The rations should be as much like fresh grass as possible.

Feeding Working Animals.

Theoretical considerations.

The theories relating to the feeding of working animals have undergone many changes within recent years. For a long while it was admitted that muscular exertion always meant a wear and tear upon the organs of the body in which the expenditure of protein was several times greater than during periods of rest. Experiments by Voit have long since demonstrated that the consumption of albuminoids is not necessarily greater during work than it is in rest. Evidently during work the circulation is more active which necessitates a greater consumption of protein in special directions, but there soon follows a compensation. On the other hand, during the activity there is necessarily greater consumption of fat than during rest, and also it must not be forgotten that during this period more oxygen enters the lungs, the combustion is greater and the caloric generated is increased; this is necessarily followed by an increased perspiration and ultimate loss of animal heat. Consequently efforts to fatten an animal doing work would be folly. The subject continues to be constantly discussed and authorities do not agree. Many of the experiments made upon dogs have led to some results of more or less importance. The writer considers it unnecessary to give numerous tables, showing that the consumption of protein is entirely independent of work done as mentioned in the foregoing.

Interesting experiments by Henneberg upon sheep show that the muscular expenditure due to mastication and rumination have an important influence upon the loss of carbonic acid. Animals receiving their rations in the regular way threw out from the body 54 per cent. of total carbonic acid during the day; when fed at night, 56 per cent. of total carbonic acid was thrown off during the twelve hours of feeding. Numerous experiments upon horses offer for our readers matter which is foreign to our subject. As regards this question, it is interesting to mention that some authorities pretend that as the consumption of fat increases with work done, it is to this source we must look for muscular force. As the work done has its equivalent in the excess of heat produced, there is possibly a transformation of heat into work exactly as in the steam engine. Heat comes from the fuel consumed, which caloric is subsequently transformed into power in the receiving receptacle. From this it is concluded that it is mainly from the carbohydrates that heat is obtained, and the resulting force is only 20 per cent. of the total caloric, which results are however superior to the very best mechanical appliances. This is only theory and does not agree with the facts of the case. If the forces of the body represented a simple transformation of animal heat, it would be possible to keep on working night and day without the least sensation of fatigue.

If there is greater heat produced during work than in rest, this is compensated by the increased perspiration which establishes an equilibrium. Some years since it was declared that when feeding animals during excessive work, their rations must contain considerable protein, and a comparatively small amount of carbohydrates. The function of protein is not to produce power, but it is essential for muscular activity.

Recent experiments, on the other hand, show that carbohydrates, such as sugar, actually mean strength. There can be no doubt that animals store up a certain amount of power in various forms. Max Rübner has demonstrated that dynamic equivalents of nutrients are almost exactly equal to their caloric equivalents. It is, however, to Stohmann that the credit must be given of this interesting discovery. It has been demonstrated that 100 parts of fat have the following equivalents:

EQUIVALENTS FOR 100 PARTS OF FAT.

	Number obtained directly.	Calculated.
Myosin	225	213 = 4424 calories.
Starch	232	229 = 4416 "
Cane sugar	234	235 = 4001 "
Glucose	256	255 = 3692 "

These figures show that the different carbohydrates mentioned agree almost mathematically. Stohmann admits that the thermogenic values "of one kilo of albumin, fat and starch are represented by 5715, 9431 and 4116 calories." It is evident that the dynamic and thermogenic equivalents are different.

The factor 2.44 as admitted between fat and starch is too high. One gram of organic substances of vegetable origin, such as rye bread, represents 3960 calories. While fats and carbohydrates have important functions to fulfill in the production of power, the protein elements undergoing decomposition in the body are compared by Voit to a constant flow of water, the amount escaping through the mill-race being perfectly independent of the energy obtained. Other experiments appear to show that the decomposition of protein means an absorption of water, and the ultimate splitting up of the protein molecules means the formation of urea and fat.

Considerable albumin in the fodder helps without doubt in the production of muscular energy; when work is continued for a long period the nutritive ratio must be more contracted than when at rest. While indirectly the decomposition of protein in the body may be considered as a source of power, it must not be forgotten that the decomposition continues even during sleep.

An abundant supply of nutritive substances is not alone sufficient to produce work; the body of the animal fed must be in a good healthy condition, otherwise there is only a partial assimilation. A weak animal with a poor muscular organism would give very poor work, even when well fed, as compared to one whose muscles are in prime condition. In fact, there is very much less oxygen stored up.

In this question of the production of work it must not be forgotten that the muscles cannot and do not work properly if the gases evolved and wastes are not constantly removed from the circulation. Gouty and rheumatic tendencies are important examples of muscular activity, due to an unusual deposit of lactic or uric acid. The theory now accepted is that muscular force depends upon the splitting up of some element making up the muscle rather than upon an actual oxidation, thus the decomposition in whatever form it may be considered depends to a certain extent upon the storing up of oxygen, which remains dormant as it were until needed. The Henneberg experiments show that most of the oxygen is taken up during the night, this being true not only when the animal is at rest, but also when working. As regards carbonic acid, the reverse is true, viz., most of the carbonic acid is thrown off during the day and the amount increases with work done. An important fact is that the storing up of oxygen seems to depend upon the amount of protein fed.

Muscular activity always means an expenditure of fat and carbohydrates, hence there can be no doubt of the importance of a fodder containing a sufficient supply to meet almost any emergency. Additional fat is a very important element in the production of work, and it is not surprising that the working classes as such depend so largely upon fatty foods. This subject of production of work from foods has been reduced to a science, and among the most important results in this special direction are those of Sanson. The problem is to establish a proportion between the work done in raising one kilo one meter high, and the energy of a kilo of protein combined with fatty substances and carbohydrates.

The mechanical equivalent of one kilogram of protein corresponds to 1,742,500 * kilogrameters of work; and consequently an animal fed can develop that amount of work without loss of weight. To compose a ration that would fill all the requirements of the case, the distance traveled in a unit of time, the effort consumed, and the total time during which work lasts must be considered.

If K represents foot pounds, P protein, and X the number of foot pounds that 1 lb. of protein will produce, we shall have the following equation: $K = P \times X$, consequently $X = \frac{K}{P}$. This proportion is frequently termed the mechanical coefficient of protein. In experiments upon horses, it was shown that by subtracting from the protein consumed during work the protein

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* One kilo of protein = 4,100 calories; one calorie = 425 kilogrameters. $4{,}100 \times 425 = 1{,}742{,}500$ kg. m.

consumption during rest we obtain the protein requisite for work produced. In such calculations it is well to consider the digestible protein; in fact, upon general principles we may admit that the working powers of an animal depend upon its digestive activity.

Again using the above formula, we have:

$$K = P \times 1,742,500.$$

Consequently if we have a ration consisting of known fodders it is possible to determine the work it can produce. In a few words, the calculation consists in determining the raw protein of the ration and the coefficient of digestibility.

Work done = Crude protein × Coeff. of digestibility × 1.742.-500. If the work is known in advance the protein necessary may be determined by a very simple calculation.

Upon general principles it must be admitted that an animal will not develop muscular force unless its muscles are in good condition, which means health. The amount of albumin deposited in the organs and in the circulation must be sufficient to supply the demands for the production of work. Under special conditions the mechanical energy developed may be increased by using a very concentrated ration.

Working oxen and cows.

The working of cows and oxen on farms is not practiced in this country as in Europe, consequently the subject has for us only a secondary importance. The ration of an animal doing work must necessarily differ from one being stall fed, and the appetite is greater owing to the effort of nature to restore tissue consumed during work. Instead of the standard given for growing cattle, we can increase the quantity of beets $\frac{1}{2}$ lb. per diem and slightly decrease the cotton seed cake. The proportion for each would then be 35 per cent. of total dry matter furnished by beets, 17 per cent. hay, 13 per cent. wheat, 18 per cent. cotton-seed cake, and 18 per cent. malt sprouts. For animals 12 to 18 months old and consuming 18.5 lbs. dry matter per diem we should have a ration as follows: Beets 46 lbs., clover hay 3.7 lbs., wheat straw 2.7 lbs., cotton seed meal 3.7 lbs., malt sprouts 3.7 lbs. Under these circumstances there would follow an increase of weight of about $\frac{1}{10}$ or 1.8 lbs. per diem; if at the commencement of the season the animal weighed 770 lbs., its weight would be after six months about 1,000 lbs.

As many cows are worked during their gestation, it is of great importance not to give them beets that are even slightly fermented. It is the custom on some farms to prepare the ration and allow it to subsequently ferment, but there is constant danger under these circumstances of bringing about a miscarriage. Young oxen through this feeding may work and gain in strength and weight; the ration then undergoes a slight change, and contains a heavier percentage of coarser fodders. After the end of the third year they attain their maximum working weight. There are many arguments as to the comparative advantages of working an animal that is to be subsequently fattened, and of allowing it to remain idle for over two years.

Oxen when doing light work do not require very much more fodder than is needed for their maintenance; on the other hand, if extra work is demanded of them, it is important to furnish per 1,000 lbs. live weight about 1.6 lbs. protein and 12 lbs. of non-nitrogenous substances, the nutritive ration being then, 1:7.5.

Rations in General.

General remarks.

The Wolff tables are calculated on a basis of 1000 lbs. live weight per diem. Several French authorities justly point to the fact that these figures are not based upon thoroughly scientific facts. Little or no allowance is made for the difference in the assimilating powers of certain races of large and small animals, no account is taken of the age of the cattle being fed, and there is no effort at economy of fodder used, when a little more or less in certain cases would bring about very different results financially. It is most difficult by using these standard rations to ascertain their economic working. It is also pointed out that a knowledge of the average temperature in the stables is necessary, and that in reality the daily rations should vary with the ambient temperature. When every fact is considered, it remains to be thoroughly proved whether the best ration should not be governed by the appetite of the animal being fed. We do not in our present writing consider it worth our while to enter into those very complicated theories based upon the caloric necessary to keep up the animal's consumption. Furthermore it was proposed that the ration should vary with each animal, as the cube root of the square root of the animal's weight. All chest measurements for weight of ration are also very empirical, as the expansion of the chest is by no means constant and varies from minute to minute; a variation of one inch in these measurements makes a very considerable difference in the results obtained. So all facts considered the standard may be the best guide. It may, however, be desirable to have tables for an average weight and to decrease or increase same, as may be, remembering in all cases that a small animal eats more, proportionately, than a large one does.

Standards. Animals of given weight, age and kind, are capable of eating a certain amount per diem. An average in each case has led to certain standards upon which the whole art of cattle feeding depends. Hence well-arranged tables point out just what amount of protein and fatty substances should be fed to cows being milked, or cattle going through the process of fattening. To remain within rational limits, it is important to be constantly watching the condition of excrements thrown out by each animal fed, as if it is receiving that which it cannot digest, there will soon be evidence of this in the excrements, and the ration then should be altered until normal conditions are reached. Practical experiments appear to show that the digestive capacity of cattle is about 2 to 3 per cent. of dry matter of their weight. Upon this basis one can approximate the maximum feeding capacity of the product on hand for a given period.

All standard rations are based upon the supposition that the stable is kept at a temperature that varies from 12 to 20° C. In exceptional cases, during winter for example, the temperature is very much below this standard; under which circumstances it becomes important to increase the percentage of heat-forming elements, and in such cases beets may render good service. The caloric is thus furnished to the animal and he is not obliged to abnormally exhaust those elements for heating the body which should be otherwise utilized. The carbohydrates and fatty substances are particularly desirable. It has been recommended that the carbohydrates be increased $\frac{1}{12}$ and protein $\frac{1}{20}$ for every 5° C. fall below 12° C.

Variation in standards.

The composition of a ration should vary not only with the animal but with the object in view. If it is simply to keep the animal in good condition, then its fodder would be a maintenance ration. In case of cows giving milk there is another element that must be considered besides that of furnishing the body with its requirements, which is that of meeting the drain that the milk production requires. While animals may be made to feed upon stuffs that their nature did not originally intend, they do not under these circumstances retain their original constitution. Animals, for example, in zoölogical gardens are kept alive on foods that they would have declined under normal conditions. There follows a great change in their characteristics. When the question of fattening is to be considered, then the problem is to force the consumption of rations, which is accomplished by furnishing an ample amount of concentrated stuffs, and these may consequently be considered as additional rations. Just as man eats bread to represent volume in the stomach, which is one of the essentials of perfect digestion, live stock must have a certain amount of coarser elements added, the volume of these depending upon the cases under consideration. The coefficient of digestibility depends upon the age of the animal; when very young it requires considerable protein and phosphoric acid, and the nutritive ratio should be as near as possible to that of green grass. As the years advance the ratio gets smaller. Calculations of this kind are no easy matter, and are not within the power of an average farmer; but we consider that very accurate results may be obtained from certain practical rules.

Variation in ration.

Rations should vary in their composition. Whatever be the advantage claimed for cossettes, beet leaves and their varied combinations, it is never desirable to keep the ration of the same composition for too long at a time, as live stock in general, like men, need a change in the diet, and their general health is improved in a very important measure by these changes. The variation should not consist in a different food at each meal of the same day. Cows or live stock are individuals of habit, and expect their ration during the period of special feeding at the same hour and of the same kind; in other words, the first meal should not necessarily be the same as the second, but on each successive day let it be identical at the same hour, otherwise there would certainly be a falling off in the expected results.

It is a great mistake to change the ration too suddenly. Even with fodders of the very best quality there is a falling off in the flow of milk after a change is made, and no condition is more important for an abundant supply of milk than the uniformity of regime.

A precaution too frequently overlooked is to arrange so that the summer ration shall be in reserve in sufficient amount to meet every possible emergency caused by bad weather, etc., and the same may be said of winter rations. In case fermentation occurs, the reserve can be drawn upon. The supply of beets and beet pulp now renders excellent service.

Appetizing rations.

The success of cattle feeding frequently depends upon the art of presenting the ration in the most appetizing form and thereby realizing an abnormal consumption; and as for milch cows, the more appetizing the ration is the better, upon general principles, will be the milk, and herein may be found the exceptional advantages of the sugar beet and its residuum—it is always eaten with avidity. A custom that has certainly led to very unsatisfactory results is to simply throw the various compounds of a ration into the manger without any attempt at mixing; this is a mistake, and never leads to satisfactory milk production. Experience appears to show that it is best to give the more palatable ration in the morning, while the roughage is placed at the cow's disposal for night-feeding.

Distribution of rations.

The number of meals per diem and of what they should consist vary with each kind of animal being fattened. Regularity in feeding is the basis of success. Animals that are worked must necessarily have a longer interval between their meals than those that are stall-fed. Whatever plan is adopted, it must be adhered to. Cattle become restless when the meal hour approaches, and if irregular the wear and tear on their constitution does away with all beneficial effects that would be otherwise obtained. The meals should not all be of the same kind; they should, within a reasonable extent, differ not only as regards quantity but composition; it must be borne in mind that these differences must be very slight, as they would otherwise be followed by digestive complications. Hence the importance of passing very gradually from stall-feeding to pasturage. It is important to watch the supply of fodders on hand, and when one is low and a change must be made, arrange to effect the same gradually, at least 8 to 10 days being necessary for these changes of diet.

Commercial Value of Fodders.

All existing modes of estimation of value very empirical.

The Germans employ much technical detail to determine the value of fodders, which in reality is a most simple question, and is governed by the supply and demand. The price of a commodity must necessarily vary with the advantages of its production in the center where it is sold. The writer intended to give an average price of the standard fodders for the United States, but was obliged to abandon the project owing to the great difference in the value of a staple such as hay; it may fluctuate from a few cents per ton to several dollars (15 to 20). The German method consists in accepting hay as a standard and to allow a pro rata value for the digestible elements of which it is composed; knowing the composition of any fodder, its crude protein, fat, etc., are multiplied by the standard prices and its commercial value is thus obtained.

One need only make a calculation of this kind and compare the price obtained with the market rates to realize how far such theoretical considerations are from the reality. Another point not to be forgotten is that whatever be the fodder used, it must necessarily contain several elements that are not utilized in the manner that theory supposes, under which circumstances, if we place a money value upon them, we shall pay for an ingredient that is wasted, and this would certainly not be in accordance with the true principles of economy.

Money modes of calculation.

Place a definite price per pound on protein, fat and carbohydrates, the data being based upon the average market price, which is about as follows: Protein 1 to 2.5 cents, and carbohydrates from 0.5 to 1 cent per pound. The advantage of this data is that it is supposed to enable the farmer to calculate in advance what fodder is to his actual advantage. While the market prices of cotton-seed meal and gluten meal may differ only by one dollar, the actual feeding value may vary $10. It is interesting to note that the nutritive money value as admitted in the United States is very different from that adopted by Kühn, who declares that if the carbohydrates are worth one cent per pound, the digestible fatty substances would then be worth 2.44 cents and the protein digestible constituents, 6 cents.

However, even the caloric basis of estimation is very misleading, as the formation of flesh and fat, the flow of milk, etc., depend upon other physical conditions than simple generation of heat. It becomes evident than even in this case, it is impossible to obtain results that are more than approximatively correct. The only true basis that might be suggested is the actual analysis of each fodder used, and this would be too complicated to have any practical value. A fact too frequently forgotten is that to a farmer the most valuable fodder is not the greatest milk and meat producer, but the one that can accomplish this at the least possible cost.

If of two fodders, one yields two pounds of digestible matter, and the other only one pound, then the one fodder is twice as valuable as the other for nutrition, irrespective of the market price. The price of meat is not so variable throughout the country as the price of seeds, so we may base estimates upon it. To produce this pound of beef, there must be consumed a certain quantity of protein, fatty substances, and carbohydrates, and this consumption must necessarily vary with each animal. If we could establish an average, then we could approximate the value of each of the elements upon which this meat production depends.

Purchasing feeds. It is always recommended when purchasing feeds to obtain a list of market prices and determine by a very careful calculation which is the most desirable for the object in view. Such efforts may mean a daily saving of ten or twelve cents per ration per diem. The calculation should be largely based upon the manner in which the protein may be obtained under the most economical conditions, and these data always vary not only with the feed, but with the year.

It is important that the farmer should know when purchasing feeding stuff just what its source and its nature are. Considerable fraud frequently exists in this respect, and various wastes are introduced upon the market that have only a secondary nutritive value.

The New York Agricultural Experiment Station proposes the following rules:

1. A ration to contain 30 to 45 per cent. protein and 50 to 60 per cent. carbohydrates: Cotton seed meal, linseed meal and gluten meal.
2. A ration to contain 20 to 30 per cent. protein and 66 to 70 per cent. carbohydrates: Gluten feeds, dried brewers' grain, malt sprouts, buckwheat, middlings, etc.
3. A ration to contain 14 to 20 per cent. protein and 70 to 75 per cent. carbohydrates: Middlings, from wheat and rye.
4. A ration to contain 8 to 14 per cent. protein and 75 to 85 per cent. carbohydrates: Cereals, grains, hominy, etc.

Cost of rations.

The cost of the ration should be as low as possible, so that the results obtained will be at least equal to cost of fodders. Just within what limits the farmer can profitably grow his own fodders is a question we cannot here discuss. All things being equal one fact is certain, he saves the cost of transportation. Oil meal for example can be more profitably utilized for milk production near large cities than it could be for cattle fattening on distant farms. Oats are more suitable for feeding working animals than they would be for stall-fed cattle. Consequently one must take into consideration the value of the product used. If the farmer has not on hand any so-called concentrated fodder, it becomes of the first importance that he purchase what is needed from outside. Fodders must be considered collectively and not separately.

PART SECOND.

Feeding Beets to Cattle.

Preliminary remarks.

It frequently happens that the beet crop is very large, due to careful cultivation, or to neglect. In the latter case the roots are big, and cannot be advantageously used at the factory. If these are left on the hands of the farmer—as is frequently the case—he becomes discouraged, and hesitates to renew his efforts at sugar-beet cultivation. If, on the other hand, he can find a profitable use for his roots as feed, he will consider beets from an entirely different standpoint. On several farms to which the writer's attention has been called, beets have been fed to cattle, and the fact has now become a source of trouble to the manufacturer.

In these cases, the farmers argue that they can make more money by feeding direct than by selling roots to the factory, with the idea of subsequently utilizing the refuse pulp (?).

Many farmers throughout the country are willing to contract to grow small areas of beets and to subsequently use the roots for cattle-feeding; the results have been most satisfactory to all interested. Capitalists can form some idea of what the chances are for a satisfactory crop of beets in any given vicinity, and the farmer, in the meantime, is gaining experience with this special crop at no money loss to himself. The advantages that have followed the introduction of a succulent ration with corn have long since been recognized everywhere in Continental Europe.

In an emergency, beets may be used for feeding cattle, but it is a mistake to suppose that more money is to be made from milk and flesh by feeding roots direct than is possible by use of the product after sugar has been extracted. It is also a mistake to imagine that large beets * give the best results; it is unnecessary to enter into a dollar-and-cent argument which would be beyond the scope of the present writing.

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* The total dry matter contained in roots diminishes with their size. Sugar beets are very poor in nitrogen, but their percentage of dry matter is com-

Preparation of beets before feeding.

What nature does in the field, science must accomplish in the stable, which is to furnish to the animal being fed a ration that is not only suited to the daily requirement, but that will be eaten with relish.

Many farmers make the mistake of attempting to feed whole beets to cattle. Under such circumstances the results obtained are not what they should be. Beets should be properly sliced and combined with other fodders. The size of the slice has an important influence; if too large, there is danger to the animals from choking, and several instances of this are on record. This difficulty is never to be feared when using residuary-diffusion cossettes from factory. The importance of a thorough crushing, grinding, or slicing, as the case may be, is made evident when we consider that the digestibility of fodder depends upon its combination with the gastric juice of the stomach; and when the assimilation is not what was expected, it may be largely due to the improperly-prepared food that was used.

Steaming or cooking.†

In certain cases there are important advantages to be derived from warming or cooking fodders; the practice, however, as to beets is by no means general. Cows are willing to eat more warm food than cold, which fact realizes the desired end, that of increasing their weight. Furthermore, steaming 10 to 15 minutes, at a pressure of three atmospheres, has the effect of reducing to a homogeneous mass the straw and general waste

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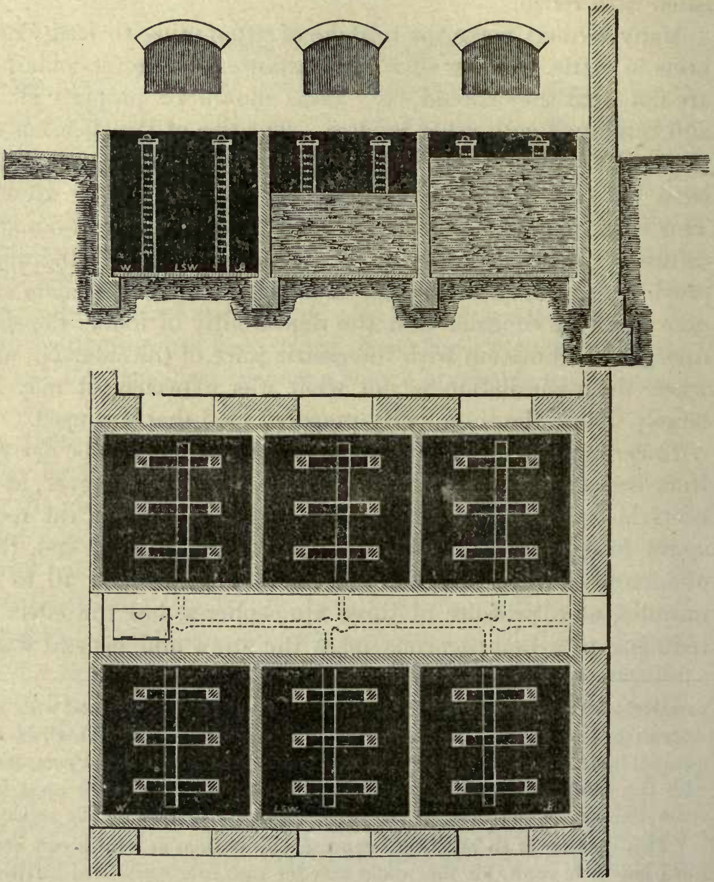
paratively high. In very large beets grown upon highly manured soils, not more than ½ of their percentage of albuminoids is nitrogen. This fact frequently leads to error, as the ultimate results obtained are not compatible with the theoretical feeding value of the roots used. Sheep fed upon beet roots digested 98 per cent. of the carbohydrates contained in the ration.

† This cooking is an additional expense: calculations as regards cost would have but little value, for this would vary for each case considered. It is for each farmer to determine whether the operation is profitable or not. The early theories respecting steam driving out alcohol, and other volatile substances that would be irritants, are most amusing. Certain farmers went so far as to assert that during certain epidemics of pneumonia, cattle fed upon fermented beets not steamed, died, whilst others receiving regular rations of sliced and cooked beets lived through the plague.

around the barn, that are combined with beets in proportions depending upon scarcity of standard fodders; 75 lbs. steamed beets *per diem* is a good average. Under all circumstances, straws used should be properly chopped. In some cases the importance of cooking is very evident. With hogs, the increase of weight after cooking of the food is very striking.

FIG. 1.



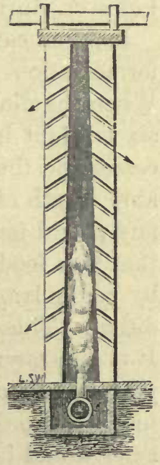
Vertical and Horizontal Section of Leduc's Beet-Steaming Pits.

A description of a steaming process, combined with fermentation, is of interest. The mode given herewith is the one used on Mr. Leduc's farm at Beaurevoir, France. About 125 acres were cultivated in beets, and the crop obtained was fed to cattle. It is argued that the money profits are three times greater than from land devoted to the customary pasturage. Mr. Leduc prepared the beets in two ways, the method adopted depending upon the season. In winter the roots were steamed, and in summer fermented by the natural heat. The steaming was effected in six pits, arranged in two rows of three each as shown in Fig. 1.

These rows were separated by walls, between which were located the pipes requisite for steaming; boards placed on the top of the walls permitted the workmen to fill or empty the pits as occasion might demand. At no great distance from these pits were located the beet washer and slicer, and these were connected with a stationary steam-engine, which also worked the water-pump. The necessary steam was furnished by a six-horse-power boiler. The beets were thrown into the washer by hand; after leaving it, they glided into the slicer, which may be of but cheap construction. The cossettes thus obtained were shoveled into the pits before mentioned and combined with about one-ninth of their weight of chopped straw of various kinds (colza, wheat, etc.). As to the mixing in the pits, especial care should be given to prevent this sliced mass remaining in heaps, since the steam would then not have a free circulation through it.

The bottom of each pit is properly cemented or paved and an opening is left for a pipe with six arms to supply the steam. Over each end of these arms may be found a sort of chimney, shown in Fig. 2. These are closed at the top and perforated on the sides with down-slanting orifices, which effectually throw the steam in all directions. These chimneys are placed in position only when the pits are being filled with sliced beets and straw, and are withdrawn after the steaming is finished. The steamed mass is then taken from the pits

FIG. 2.



Detail of Chimney.

and placed in cemented tanks, of a capacity each of about 20 cubic meters (26 cubic yards). The pit emptied one day is filled the next with about 10,000 kilograms (22,000 pounds), composed, as before stated, of 9,000 kilograms of chopped beets and 1,000 kilograms of chopped straw. In about twelve hours the mass begins to ferment, throwing off vapors charged with perceptible quantities of alcohol; immediately thereafter it is fed to the live stock which eat it with avidity. At Mr. Leduc's farm each calf is fed twice a day with 5 kilograms (11 pounds) of this fermented fodder, adding 250 grams of oil-cake. The fattening is effected in variable periods, depending upon many conditions; ninety days, however, is considered to be a fair average. From this we may conclude that the total consumption was 450 kilograms of fermented mass with a gain of about 50 to 55 pounds. This fermented mass may be kept in a perfect state of preservation for an entire year. Roots, on the other hand, may be preserved in silos for several of the winter months without any appreciable change in their nourishing qualities; their perfect preservation, however, during the summer is practically impossible.

Especial care is taken to compress the sliced beets so that the fermentation may be effected evenly throughout the mass. When the silos are filled, the upper surface is covered with from six to eight inches of earth. After a short time fermentation ceases and the mass is in a condition to be kept for a considerable length of time, as the carbonic acid evolved will prevent any putrid fermentation. Mr. Leduc's experiments have shown that this food is sufficiently delicate to be eaten with advantage by young lambs, as they all remained in a perfectly healthy condition. These experiments were limited to some 4,000 sheep. It is also asserted that two cows may be well kept for an entire year on 12 tons of beets, the result of one acre of land, while, under the ordinary French system of pasturing, at least three acres would be needed to obtain an equal result.

Fermentation.* A reasonable fermentation is without doubt an advantage in the preparation of rations in which beets are the basis. The operation requires considerable care, because if the proper heating limit is passed, the fodder becomes unfit food for cattle. The manner of conducting the fermentation process should depend upon the ambient temperature. It has been suggested that a series of boxes be placed near the animals being fed, wherein the mixture of sliced beets, chopped straw, (9 lbs. beets for 1 lb. straw), etc., is placed; each box to contain a quantity corresponding to the ration of the particular animal (sheep 11 lb. mixture plus ¼ lb. oil cake) being fattened. When feeding-time arrives the mass should have undergone a fermentation that gives the best results, as determined by experience.

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* The experiments of Hellriegel and Lucanus appear to show, that a preliminary fermentation of rye straw in no way increased its digestibility. Experiments of Hornberger show that steaming of certain fodders, such as meadow hay, diminished very considerably the digestibility of its protein.

Maceration.

The main object of this process is to soften those portions of a fodder that would not be readily acted upon by gastric juice. When in contact with water these particles swell and break open, greatly increasing their digestibility. The influence of water upon a mixture of sliced beets and straw is made evident by the fact, that when the operation is thoroughly performed, the digestibility is increased nearly 50 per cent. Maceration may render excellent service in case of feeding mother beets to cattle; these, after the seed stalk has been cut off, are more fibrous in their composition than normal beets. Roots of this kind contain very little sugar, considerable ash, and are very watery.

Comparative Experiments.

Beets and pulp compared.

A series of experiments were made in France some years since to determine practically whether sugar beets direct from the field had any advantage over pulp obtained from factory. In these practical trials ten cows of about the same weight were used; the five fed with beets weighed 5,100 lbs., the five fed with pulp weighed about the same. During the experiment one half received 172½ tons of beets and the other 189½ tons of pulp. The five cows fed with beets gave 1,136 quarts milk that contained an average of 39.9 per cent. fatty substance; the five fed with pulp yielded 1,104 quarts milk testing 33.9 per cent. fatty substance.

No special difference could be noticed in the taste of the milk in either case. The butter from the pulp-fed cows was of a fine yellow color. Numerous other examples could be given, among which may be mentioned extended experiments in feeding 1,660 sheep for 120 days with beets. The ration consisted of 11 lbs. beets to 1 lb. hay, 1.1 lb. oil cake and 1.1 lb. straw. The increased value of the sheep was two dollars per head. The same experiments were repeated with diffusion beet-pulp, and the conclusions were, that this residuum was much more profitable than beets direct from the field.

Other experiments upon sheep were made to determine just what the relations were between the feeding value of distillery pulp and sugar beets. The daily rations during these experiments were, for the first week, 6.6 lbs. fermented beet slices, 2.2 lbs. hay, 0.7 lb. straw and 0.4 lb. chopped straw. During the second week the amount of beets and pulp fed *per diem* was increased to 13 lbs.

After 84 days the total increased weight of the sheep fattened with beets was 19,250 lbs., while with pulp it was 16,000 lbs. The average weight of manure obtained with beets was 8.4 lbs., with pulp 11 lbs.; the quality for fertilizing purposes of the pulp manure was inferior to the beet manure. The conclusions were that 100 lbs. beets have the same value for feeding purposes as 180 lbs. pulp. If beets sell at the factory at $4.00 per ton, the cost of the total ration would be 18 cents; if pulp can be purchased at $1.50 per ton at the factory, the total ration will cost 12 cents, which shows that pulp is decidedly more profitable for farmers' purposes than beets.

Sugar beets and mangels compared.

Experiments were made to determine whether there was any advantage in feeding a beet of the mangel order over the use of sugar beets of a satisfactory quality, cultivated according to the now accepted rules of close planting. Evidently it costs more per ton to cultivate a good beet than a root belonging to the same family, but receiving comparatively little attention. The experiments we have under consideration were made in 1898–99, and were conducted in three series; in each lot of sheep fed there was the same number of animals, and they were furnished with a weight of roots obtained from a given area regardless of their feeding qualities; under these circumstances the results obtained were comparable. The roots of the mangel type were known as the Tankard, and two varieties of sugar beets were used, one from mother beets testing 10 per cent. sugar and the other a rich rose-neck beet, the seed having been obtained from a mother beet testing 15 per cent. sugar. The Tankards were cultivated in rows 20½ inches apart, the spacing in the rows being 23½ inches; the average beet was planted in rows 11.7 inches apart and spaced at 17½ inches, while for the superior beet the rows were 11.7 inches and spacing 15½ inches. When the beets were harvested their analysis and weighing showed the following results:

COMPARISON OF TANKARD AND SUGAR BEETS.

	DRY SUBSTANCES, Per acre.	YIELD, Per acre.
Tankard	6,332 lbs.	18 tons.
Average beet.	7,779 "	17.6 "
Superior beet.	7,260 "	14.8 "

It will be noted that the dry matter per acre is in favor of the beets.

The ration of Tankard beets was 6.6 lbs per diem, while of the average beet the allowance was 6.4 lbs., and of the superior beet the weight fed was 5.3 lbs., these being all obtained from an equal superficial area.

The beets were sliced into cossettes and combined with 0.4 lbs. of wheat balls per animal. The mixture was made 24 hours in advance, so as to allow for a certain fermentation. An allowance of 2.2 lbs. of hay was also fed to each sheep. The ration was divided into two parts, which were fed at separate times, and the sheep had placed at their disposal salt and water according to their special individual requirements. The experiments on each lot of sheep lasted for twenty days with each variety of beet being tested.

The increase in weight of the sheep considered in lots was as follows:

COMPARATIVE INCREASE IN WEIGHT OF SHEEP FED WITH TANKARD AND WITH SUGAR BEETS.

	TANKARD.	AVERAGE BEET.	SUPERIOR BEET.
First lot of sheep	7.0 lbs.	15.2 lbs.	9.7 lbs.
Second lot of sheep	6.4 "	13.0 "	10.3 "
Third lot of sheep	3.9 "	9.9 "	8.3 "
Total	17.3 lbs.	38.1 lbs.	28.3 lbs.

The argument that necessarily follows upon the examination of these figures is that the average beet is very superior to the other two, but even the superior beet gives more profitable results from a fattening standpoint than does the mangel. If we consider the cost of cultivation of the several varieties of beets tested, it stands to reason that more seed is needed for rows 11.7 inches apart than for rows separated by 20½ inches; the weeding is also more difficult and expensive in the latter than in the former case, this being also true for the harvesting for the reason that there are more beets to collect from the field. All facts considered, it was found that the surplus cost in this case was $2.40 per acre over and above that existing for roots cultivated at greater distances between the rows. The value upon the market of the increased weights in question was $1.26, $2.80 and $2.26 respectively. If we bring into our calculation the cost of production, we find that the profit from the average beet was $46 per acre and from the rich beet only $31, while for the Tankard it was very much less. These results show beyond cavil the importance of growing beets, even of an average quality, according to accepted rules of close planting when intended for feeding purposes, rather than to attempt cultivating roots of low grades and by methods already too long continued. The increased profits more than compensate for the extra cost and trouble.

When growing roots for cattle-feed, remember that a root of a moderate size is wanted, not over 3 pounds being a moderate yield, as the larger the individual root the lower will be its nutritive equivalent. If we determine the pounds of plant food taken up per ton of mangels and beets, with their leaves, we would have the following average analysis:

PLANT FOOD TAKEN UP BY MANGELS AND SUGAR BEETS.

Crop Grown. One ton each.	Nitrogen.	Monoxid of potassium. K_2O.	Monoxid of sodium. Na_2O.	Oxid of calcium. CaO.	Monoxid of magnesium. MgO.	Phosphoric acid. P_2O_5.	Sulphuric acid. SO_3.	Chlorin. Cl.	Silicic acid. SiO_2.	Total ash.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Mangels, root	4.3	8.7	3.4	1.1	0.9	1.5	0.6	1.8	0.7	38.2
Mangels, leaf	2.3	3.2	3.1	1.3	1.2	0.6	0.8	2.2	0.5	
	6.6	11.9	6.5	2.4	2.1	2.1	1.4	4.0	1.2	
Sugar-beets, root with necks	5.3	7.7	1.6	1.0	1.5	2.3	0.7	0.3	0.6	34.5
Sugar-beets, leaf	2.1	2.6	1.9	2.2	2.1	0.8	0.9	0.6	0.3	
	7.4	10.3	3.5	3.2	3.6	3.1	1.6	0.9	0.9	

This shows the ash absorbed by growing one ton of *mangels* to be 38.2 pounds, while with *beets* it is 34.5 pounds, thus proving mangels more exhausting to the soil than sugar-beets. If we admit that *20 tons of mangels* may be grown to the acre, a total of 764 pounds of plant food will be absorbed. If 10 tons are an average yield to the acre for sugar-beets, the ash taken up by that crop will be 345 pounds. Consequently we are not far from correct in asserting that by neglectful cultivation it will take one-half the time to ruin the soil in growing mangels that it does with beets. If, on the other hand, scientific rules of cultivation are practiced when growing beets, the diminution of the fertility of the land need not be dreaded. Beets raised for a sugar factory should, on general principles, have their necks and leaves sliced off before they are hauled from the field where they were grown, then the greater portion of the salts, etc., taken up is returned. Those varieties of mangels raised for stock feed grow nearly as much above as beneath ground, especially when manured by the leaf-stripping. Neck slicing is not effected, for the reason that it would diminish by nearly one-half the yield of the crop, under which circumstances it would not be profitable. The conclusion is, that those farmers who grow mangels for other purposes than their own stock use, are practicing a system of husbandry not to be encouraged.

Sugar-beets compared with rutabagas.

From time to time it is urged that rutabagas be more extensively cultivated, it being argued that the farmer in the long run would derive more actual advantage from such a crop than is possible from sugar beets when the object in view is cattle-feeding. We are willing to admit that the yield per acre is greater with rutabagas than with sugar beets, but there are other issues to be considered besides the yield. Upon general principles the main effort in sugar-beet cultivation has always been to increase the sugar percentage and dry substances contained in the beet, rather than to obtain as far as possible heavy yields. With rutabagas on the other hand the aim has always been to get heavy yields regardless of every other condition, and as a result 36 tons have been obtained to the acre. Sugar-beets may be said to contain from 75 to 90 per cent. water; in the case of rutabagas with heavy yields the root is very watery and contains only about 10 per cent. dry substances. The table herewith shows the analysis of a rutabaga of a heavy yield variety and of a superior type of sugar-beet:

COMPARATIVE ANALYSES OF A RUTABAGA AND A SUGAR-BEET.

VARIETY.	Water.	Dry substances.	Nitrogenous substances.	Fatty substances.	Carbohydrates.	Mineral substances.	Cellulose.
Superior sugar-beet	81.0	19.0	2.3	0.2	14.6	0.7	1.0
Rutabaga	91.1	8.9	1.3	0.1	6.3	1.1	0.3

The actual nutrients are in far greater proportion in the sugar-beet than in the forage variety. Consequently when feeding, weight for weight, the two kinds of beets, the benefits that will accrue will be much greater in one case than in the other. It must be thoroughly understood that we do not recommend high testing beets for cattle-feeding, but on the contrary, a variety containing 10 per cent. sugar rather than the forage types, averaging about 5 per cent. The difference in the total dry substance in the two cases would not be much less than 1,000 lbs. per acre, an amount which means considerable additional money returns. The cost of cultivation for the heavy yield varieties is less than when cultivating in rows nearer together; but this difference is very slight in comparison with the actual advantage gained. At the present time many of the European seed-growing specialists are concentrating their efforts to create what is known as a semi-sugar-beet, possessing certain characteristic qualities of a superior and inferior beet. If this problem can be solved the farmer would then have a crop at his disposal which he could for a term of years cultivate and become accustomed to, without losing money in awaiting the building of a beet-sugar factory in his vicinity. A well-known agronomist has made some experiments with the new variety in question, the results being as follows:

COMPARATIVE YIELDS OF FORAGE AND SEMI-SUGAR BEETS.

	YIELD TO THE ACRE.	
	Forage beet.	Semi-sugar beet.
Yield	14 tons.	16 tons.
Dry substance	4,000 lbs.	7,000 lbs.
Sugar	2,300 "	4,400 "
Nitrogenous substance	202	350

This means an excess of 3,000 lbs. in favor of the new variety for dry substance alone. In these special experiments the excessive drought had an important influence on the yield of the forage variety. We consider these facts are of sufficient moment for our leading agricultural stations to give the subject their special attention. They would thus do considerable towards advancing the prosperity of the tiller in their respective sections.

Green corn fodder vs. sugar beets for cattle feed.

The question of ensilage has for many years attracted much attention throughout the country, and the subject is interesting and worthy of every agriculturalist's consideration.

By supplying an economical green fodder to live stock during the winter months milch cows may be kept in an excellent condition. For many years past, farmers of the southern parts of France have successfully adopted a system of green corn ensilage, which, in the generality of cases, has given excellent results. As to its profitable application in the United States, experiments have led to very contradictory results, and in consequence we are not prepared either to recommend or condemn the practice from a financial point of view. The silos generally used are built of masonry and internally cemented, their cost depending upon their capacity. If but few cows are to be fed, the siloing of their food would not be judicious, as the cost of the fodder per pound would then be considerably increased. Before the green corn-stalks are placed in the silos they are sliced and mixed with chopped straw. The hauling of the stalks to the site of ensilage, their preparation, etc., are all operations the cost of which depends upon the facilities offered. When in large quantities the bulk would evidently considerably diminish its cost of transportation per ton. As regards this many enthusiasts contend that, under favorable circumstances, it may be accomplished at forty cents a ton.

While excellent results may be obtained by feeding ensilaged green corn to cattle, the exhausting effect this practice has upon the soil should not be overlooked. Many farmers are well aware of the importance of "plowing under" corn stalks after the corn harvest is over, in which case the soil gets back a large percentage of the elements absorbed by the plant in growing. On the other hand, if green corn is fed to cattle, and if the resulting manure is spread on the soil, a portion of the plant-food will be lost—this fact applies to fodders in general. If a comparison be made between the exhausting effect from growing one acre of green corn, and the same area planted with sugar beets, it will be found that the latter crop, although not as nourishing as the former, is by far the more beneficial to the soil, and not nearly as exhausting. In comparing mangels with sugar beets, we have previously called attention to the percentage of plant-food taken up by one ton of beets and mangels. In the same manner we may compare the most important of these elements absorbed by one ton of green fodder with those of one ton of beets.

Plant Foods Absorbed by One Ton of Sugar-Beets and Green Corn.

	Potassa.	Soda.	Magnesia.	Lime.	Phosphoric acid.	Nitrogen.
Sugar-beets	7.7	1.6	1.5	1.0	2.3	5.3
Green corn	4.3	0.5	1.4	1.6	1.3	3.2

These figures prove that, ton to ton, sugar beets are more exhausting than green corn; but if we admit that the yield of green corn is twice that of sugar beets, we would obtain the following figures:

Plant Foods Absorbed to the Acre by Ten Tons of Beets and Twenty Tons of Green Corn.

	Potassa.	Soda.	Magnesia.	Lime.	Phosphoric acid.	Nitrogen.
Green corn	86	10	28	32	26	64
Sugar-beets	77 lbs.	16 lbs.	15 lbs.	10 lbs.	23 lbs.	53 lbs.
	9	—6	13	22	3	11

In other words, green corn takes up per acre 6 lbs. less soda, 13 lbs. more magnesia, 22 lbs. more lime, 3 lbs. more phosphoric acid, and 11 lbs. more nitrogen.

These figures are apparently insignificant, but when the deficiency in the soil is to be made up, the dollar cost of the fertilizers over and above that required after a beet-crop, is worthy of consideration.

If we compare the total nourishing qualities of twenty tons of green corn before ensilage with 10 tons of sugar beets, we shall find that the total of digestible nutrients is 3,320 pounds for green corn and 3,560 pounds for sugar beets, or a difference of 240 pounds. Such are the facts at the harvesting. After several months have elapsed, the ensilage has undergone considerable change, and its volume has been purposely diminished by weights placed on its upper surface. If great care has been taken in preparing this ensilage, there is but slight danger of excessive fermentation caused by oxygen remaining imprisoned in the mass. If we compare these difficulties with the simple siloing of beets, it will be readily seen that these roots, for winter feeding, offer many advantages over green corn-fodder. Their siloing may be effected at a nominal expense on the ground upon which the roots were grown, it being then simply necessary to place them in triangular piles and cover their outer surface with a thickness of earth varying with the severity of the winter. There they remain for several months, undergoing practically no change in nourishing qualities. Their consumption need take place only when required at the stable. The farmer consequently need not make an immediate outlay of money for building silos, or hauling the entire crop without delay, whereas it is admitted that the quality of green corn fodder decreases slightly a few days after cutting, if not siloed at once.

Large and small beets in cattle-feeding.

Many farmers are under a very erroneous impression regarding the value of reasonably small beets for cattle-feeding, and continue in some of the New England States to cultivate mangolds with considerable distance between rows; they thus obtain crops of 30 and 35 tons to the acre. Some of these roots have an individual weight of nearly 20 lbs.; analysis would show them to be of a very spongy texture and to contain not more than 8.5 per cent. dry matter and 91.5 per cent. water, holding in solution about 6 per cent. sugar. Such roots are frequently fed to cattle during the winter in quantities corresponding to 132 lbs. per diem, or 11 lbs. of dry matter, while if small beets of this variety had been used the dry matter would have been at least 20 lbs.

During visits to agricultural fairs in several farming centres of the country, it has frequently been noticed that the rural population are attracted by these giant beets. Their use should be absolutely abandoned. If farmers persist in using mangolds let them be cultivated in rows much nearer together than they now are. The texture of the roots thus obtained will be firmer and the dry matter percentage much higher, which means a far greater fattening efficiency than has hitherto been realized.

Sugar-beets more profitable than clover-hay for cattle fodder.

If we admit that one acre of land, under favorable conditions, yields two and one-half tons of clover-hay, or about 5,000 pounds, it would be sufficient to feed a milch cow for $\frac{5000}{35} =$ 171 days, assuming that a cow's daily average consumption is 35 pounds, which figure is allowable. The total digestible nutrients which this ration contains is 16.45 pounds. Ten tons of sugar-beets contain 3,560 pounds of digestible nutrient, or sufficient to feed a cow for $\frac{3560}{16.45} = 215$ days, showing that the resulting theoretical nutritive product from one acre would feed a cow 44 days longer, if beets were grown rather than hay.

Experiments in Feeding Beets to Cows and Sheep in the United States.

Preliminary remarks.

We are convinced that the introduction of the sugar beet into farming centers of the country is destined to bring about great changes in the existing dairying process. Milk and butter will become cheaper than they now are, and the community at large will be benefited. To have during the winter months a fodder such as beet-pulp refuse from a factory, that may be purchased for a nominal sum, has advantages for stall-fed cattle that no other feed (possibly excepting corn ensilage) can offer.

Before discussing the question in all its details it is important to know first what has been done in feeding beets to farm animals in the United States. It is to be regretted that no more than a passing interest has been taken in this important subject by the leading experiment stations of the country. Most of the directors of stations realize that the question has been neglected, and they propose giving it, in the not-distant future, the attention it deserves. On the other hand, the Ohio experiment station has done some excellent work. In Nebraska the active interest shown in beet cultivation has led to a general utilization of thousands of tons of refuse pulp from Grand Island and Norfolk factories.

As farmers are not prone to scientific observation, it will fall upon the experiment stations to take the matter in hand. Prof. Nicholson says: "Next to the matter of sugar production itself, I regard it [feeding cattle on beets and beet refuse] as the most important question to be studied experimentally in connection with the beet-sugar industry."

The question of sugar-beet feeding has been very fully discussed by Dr. Goessmann, of Massachusetts, who for years used beets in rations for cattle. He says:* "Sugar-beets when fed pound for pound of dry matter, in place of hay rations, with the same kind and quantity of grain-feed, have raised, almost without exception, the temporary yield of milk, exceeding, as a rule, the corn ensilage in that direction. * * * Corn ensilage, as well as roots, proved best when fed in place of one-fourth to one-half of the full hay ration. From twenty-five to twenty-seven pounds of roots, or from thirty-five to forty pounds of corn ensilage per day (with all the hay needful to satisfy the animal in either case) seems, for various reasons, a good proportion, allowing the stated kind and quantity of grain-feed."

In comparing beets with turnips, in 1888, Dr. Goessmann said that he considered one ton of the improved variety of good sugar beets equal to 2 or 2½ tons of turnips. The experiments in Illinois commenced some years since.

In Pennsylvania Prof. Armsby has given sugar beets a most extended trial. The following statement emanates from the Pennsylvania State College Experiment Station: "It must not be forgotten that according to the standard authorities, the sugar beet and its pulp may be considered entirely digestible; furthermore, it stimulates the appetite for other fodders, which silage does not do to the same extent. However, in the feeding experiment, involving two lots of five cows each, and covering three periods of twelve days, one hundred pounds of digestible matter of the silage ration produced 131.92 lbs. of milk and 7.21 lbs. of butter; and with the root ration 137.30 lbs. of milk and 6.53 lbs. of butter. When the two lots of cows were fed alike, and on a combined ration of roots and silage, the silage lot produced per 100 lbs. of digestible matter consumed 139 lbs. milk and 6.79 lbs. of butter; the root lot 150 lbs. milk and 6.46 lbs. butter."

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* Eighth Annual Report of the Agricultural Experiment Station of Massachusetts.

Comparison of corn silage and roots for milch cows.

At the Pennsylvania State College * the supply of roots was very small and the period during which they were fed was short. Every farmer is aware, from a practical standpoint, of the increased yield of richer milk when feeding roots in connection with, or in place of, corn stored during the winter.

Feeding with roots (beets, mangel-wurzels and rutabagas) did not take the place of silage until the third week of the experiment. During one week only 31 lbs. sugar-beets were fed; the week that followed 52 lbs. mangel-wurzels were used, and these were followed by 63½ lbs. rutabagas in place of 40 lbs. silage. During the entire experiment hay was fed. The trials are to be repeated on a future occasion. It was concluded that more and richer milk was obtained while roots were used.

An interesting fact is, that while silage, etc., were constantly refused by the cows, they ate with avidity the entire quantity of roots offered. While with silage ration the average milk obtained was 14.29 lbs. per diem, the average was 18.01 lbs. with roots. The fatty matter in the milk in the first case was 0.72 lb., in the other, 0.81 lb. The water drunk with a silage ration was 36 lbs., but with root ration it was only 28 lbs. The quantity of water used continued to decrease when silage was substituted for roots.

The two cows used in Dr. Goessmann's experiments † were crosses of native stock and Ayrshires; they were at same milking periods, four weeks after calving. The daily diet of both cows consisted, at the beginning of the experiment, of 3¼ lbs. of corn-meal, an equal weight of wheat bran and all the hay they would eat. The same fodder mixture, as far as quality and quantity are concerned, was also used for some time as daily feed at the end of the experiment; the object in view was to determine the natural shrinkage in daily yield of milk during the time occupied by the experiment.

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* Report of 1890.

† Bulletin No. 22, Massachusetts Agricultural Experiment Station, October, 1886.

On examining the results obtained we find, that for one cow the yield in milk fell from 14.2 quarts per diem to 12.8 quarts as soon as 20.6 lbs. corn ensilage was substituted for 27 lbs. beets in the daily ration. With the other cow a similar change took place, but not so suddenly. The beets used in these experiments were of a kind known as Lane's improved; their percentage of dry matter was 16. With regular sugar-beets, of an imported variety, more dry matter could have been furnished for the same weight of roots eaten. In estimating the cost of feed per quart of milk, $5.00 per ton were allowed for beets that were in reality worth very much less; and in consequence the cost of the product is on the wrong side of the balance sheet.

Corn silage and clover silage vs. sugar-beets.

The Wisconsin experiments* in feeding to sheep various fodders, with the view of determining which is most profitable as a wool and meat producer, offer but a secondary interest so far as sugar beets are concerned. A flock of twenty-four sheep was experimented with, the first series of twelve being divided into three lots of four sheep each. These during the entire feeding season received daily the same quantities of grain and sugar beets; under such circumstances one cannot determine within what limits sugar beets influenced the results.

In the second group of twelve the lots also consisted of four sheep each, the object being to make a comparison between corn silage, clover silage and sugar beets. We must take exception to one assertion, that "in all cases the sheep were given as much of the succulent foods as they would eat." During the first period of one week 112 lbs. of beets were fed to all; and this was continued for three weeks. The increase of weight, which was at first 6 lbs. per week, after the third week was 16 lbs. The total sugar beets then furnished was only 84 lbs. per week, and there followed a loss of 4 lbs. One month afterwards the increase of weight per week was 16 lbs., but the week afterwards it fell to a loss of 6 lbs. without any possible reason.*

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*Eighth Annual Report of the Agricultural Experiment Station of Wisconsin, 1892.

The increase of weight during eight weeks' feeding was 28 lbs. with 756 lbs. sugar-beets, and it was 29 lbs. with 600 lbs. clover silage, but only 13 lbs. with 510 lbs. corn silage. During this period *all* the sugar-beets furnished were eaten, while with clover silage 89 lbs. were refused.

We are convinced that the sheep did not receive all the sugar-beets they could eat; the very fact that they ate all furnished shows this to have been the case. If the roots had been fed *ad libitum* we are sure that the increase of weight would have been far greater than that obtained in the experiment.

The person who had charge of these experiments said that sugar-beets "were liked by the sheep, but they cannot be said to equal either of the other succulent fodders used. They are apt to induce scouring if fed in quantities of over 4 lbs. daily to each animal." We consider that further experiments are necessary in order to determine within what limits this is true. If 4 lbs. is the limit *per diem*, why should 3 lbs. be subsequently fed?

In the experiments to determine the influence of different rations on the growth of wool, sugar-beets are not a factor in the results, so they need not be considered in the present writing.

Relative values of silage and field beets in the production of milk.

There is as much difference between field beets and sugar beets as there is between a poor mangel and sugar beets; hence any conclusions drawn from experiments in feeding field beets to cattle for the production of milk are of secondary importance as compared with the use of sugar beets; the dry matter in the two cases is very different. Experiments in feeding at the Ohio experiment station † were made with very large and coarse beets, and the results obtained are not as conclusive as if superior sugar beets had been used under the same conditions.

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* A winter ration said to give good results for rams weighing 180 lbs. is 3.3 lbs. hay, 4.4 lbs. sugar-beets and 1.3 lb. vetch hay.

† Vol. II., No. 3, second series; No. 10, June, 1889.

It is interesting, however, to note that they held their own against the very best corn silage, under the eyes of thoroughly scientific investigators.

A herd of twelve cows was sub-divided into four lots, A, B, C, D, of three cows each. Great care was taken to have the conditions in each case exactly the same, as regards characteristics and milk-producing qualities. The cows during the entire experiment were fed upon a uniform ration of 10 lbs. clover hay, 2 lbs. corn meal and 4 lbs. wheat bran. A received 40 lbs. corn silage per diem, and B 50 lbs. beets during the same interval. The following statement was made by the experimenters:

"The feeding of field beets has taught us that while most cows will take fifty pounds beets per day, without any unfavorable effect upon health or appetite, it is not always safe to feed more than this quantity; and hence it was deemed advisable to increase the dry matter of the beet ration by five pounds of hay."

In these experiments it is interesting to observe the fact, that from first to last the cows ate with avidity all beets placed at their disposal, and would have eaten more had it been given them. On the other hand, the silage refused by a single cow during a period of two weeks has been as high as 120.5 lbs. With a view to presenting the facts more plainly the following table has been prepared:

SILAGE VS. BEETS, SHOWING FEED REFUSED.

	PERIOD I.			PERIOD II.			PERIOD III.			PERIOD IV.		
	Hay.	Beets.	Silage.	Hay.	Beets.	Silage.	Hay.	Beets.	Silage.	Hay.	Beets.	Silage.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Series A, fed on silage	56.5	0	186.0	58.0	0	147.0	96.5	0	159.5	87.0	0	263.0
Series B, fed on beets	0.5	0		1.0	0		27.0	0		24	0	

The fact that three cows should refuse 298.5 pounds hay and

755.5 lbs. silage during two months, does not show that the cows experimented on were highly pleased with the rations furnished. It may be noticed that all the beets offered were eaten, and only 32.5 lbs. hay were refused. If towards the end of Period II slight changes had been made in the regime, we are convinced that all the hay in series B would have been eaten.

The fat estimation in milk does not show that there was any special advantage of silage over beets.

From the following table we conclude, that during two months the silage gave 707 lbs. milk, while beets during the same period gave 932 lbs., or a difference of 225 lbs. milk in favor of beets. The gain in weight with silage, as compared with beets, can be of no possible moment, as it is not unusual to find important differences during an interval of 24 hours.

TOTAL MILK PRODUCED, AND GAIN AND LOSS IN WEIGHT.

	MILK PRODUCED. Period.				GAIN (+) OR LOSS (—) IN WEIGHT. Period.			
	I.	II.	III.	IV.	I.	II.	III.	IV.
Series A, silage	178.0	179.4	175.3	174.2	+22	+14	+15	—3
Series B, beets	230.0	225.9	239.6	236.1	—13	+ 8	+ 1	+4

It is to be regretted that a portion of the beets was lost during warm weather, and that the roots used in the second series of experiments were large and coarse, containing but 11.69 per cent. dry matter. The inferiority of such roots becomes evident when it is known that superior beets contain 24 per cent. dry matter. Roots such as used by the Ohio station were very little superior to ordinary mangels. Under these circumstances, in order to feed beets so that total dry matter should be equal to that contained in silage ration, the weight of beets fed reached 60 lbs. *per diem.* To the rations in each case six pounds of bran were added, with good clover hay fed *ad libitum.*

These experiments showed that 14 lbs. of hay *per diem* were ample for silage-fed cows. On the other hand, the beet-fed cows consumed considerably more than that quantity; this was a very encouraging result, as previously mentioned. The principle of cattle-fattening, as already stated, is to force consumption of fodder and whatever causes this brings the desired result. While the silage ration was only 27 lbs. *per diem*, the stuff was not eaten with the same avidity as beets. The average daily yield of milk with and without beets in these experiments is shown in the following table:

AVERAGE DAILY YIELD OF MILK WITH AND WITHOUT BEETS IN RATION.
OHIO STATION, 1890.

	Without beets.	With beets.	Advantage in favor of beets.
Experiment No. 1.........	220 oz.	240 oz.	20 oz.
Experiment No. 2.........	191 oz.	214 oz.	23 oz.

During these experiments the weekly gain or loss of weight with and without beets was 4 to 14 lbs. in favor of beets. "There was a marked tendency to increase in live weight during the periods when beets were fed, and to fall off when on silage." As regards milk at the station, it was found that during 1890 "whenever the feed was changed to silage there was a rapid falling off in yield of milk, and whenever it was changed to beets this falling off was checked, and in several instances the flow increased. * * * In respect to the milk-flow, therefore, the results * * * confirm those of previous years, indicating that beets are more favorable to milk-production than corn silage."

One of the most interesting features of these experiments was the decline in live weight with a decrease in flow of milk when feeding silage, which is a most important argument in favor of beets.

Our readers should not forget that numerous European experiments point to the fact that when beets are fed all their dry matter is digested. On the other hand, experiments in Wisconsin, Pennsylvania, and other states, show that with silage 63 per cent. only is assimilated.

It is admitted that all items such as harvesting, siloing, etc., for beets, make the cost $37.75 per acre, while for producing and siloing one acre of corn requires $31.25. The silage contained 4,400 lbs. digestible dry matter, while the beets contained 3,750 lbs. of the same. This difference would appear to counterbalance the 359 lbs. of milk in favor of beets, not to mention the increase of weight. A fact in this argument that is generally overlooked is, that for the sum allowed for cultivation of one acre of beets, superior sugar beets might be obtained averaging 18 per cent. dry matter. This means a total of nearly 6,000 lbs. digestible dry matter per acre. The cost of such in beets is 0.6 c., and in silage 0.7 c. All these figures must vary with circumstances.

The cows fed solely on beets consumed 20.1 lbs. dry matter per 1000 lbs. of their weight, while silage-fed cows consumed 20.9 lbs. In both these cases the consumption was considerably below the standard of 24 lbs. The beet-fed cows were underfed, and we are convinced that if they had had the food they required, their milk-producing qualities would have been greater, and their weight would have increased instead of remaining stationary, as it did during the eight weeks the experiment lasted. It would be interesting to draw some comparison as to the cost of feeding with silage and beets. If the yield of corn and beets is about the same per acre, the siloing of corn is very much more expensive than that of beets. The exhausting effect of a beet crop upon the soil on a well-organized farm is nothing like as great as the average agronomist supposes, as at least 80 per cent. of all salts absorbed are returned in the shape of a fertilizer; the remaining 20 per cent. is in the milk sold.

The problem of fattening animals properly is to make them eat as much as possible, since at least $\frac{1}{10}$ of such food is retained and transformed mainly into fat. It is possible to reach a limit of increase of 4.5 lbs. per diem. It may seem incredible, but it is possible to force the consumption of dry matter to 44 lbs. per diem. The increase in weight continues until the end of second period; during the last period the ration should take a new shape.

As regards the foregoing experiments, silage *vs.* beets, we would say: If the Ohio station had used beets of a quality cultivated during 1891–92,* the roots would have averaged 15.5 per cent. dry matter instead of 10 per cent., as admitted in the above feeding experiments. Under these circumstances, about 32 lbs. beets would have given the same result as 50 lbs. beets such as were used, and it would have been possible to push the daily consumption very much beyond the limit attempted. It is admitted that beets in Ohio would certainly average 11 tons per acre and as their cost of cultivation, including harvesting and siloing, is $44.00, the cost per ton is $4.00 or about 0.2 cents per lb.

If we admit that corn silage is worth $2.50 per ton, its cost per lb. is 1.2 cents, consequently 40 lbs. silage costs 5.2 cents per diem, while sugar beets cost 6.4 cents, or a difference of 1.2 cents to produce 3.7 lbs. of milk. This, in itself, would be a most excellent investment. These contrasts would have been still greater had better beet seed been used. Not only would it have been shown from a milk-and-butter point of view, but also in actual gain in flesh. In Bulletin No. 2, 1892, the following statement is made: "It is possible to produce on an average as many pounds of sugar beets per acre as of mangels; and since the average analysis shows fifty per cent. more dry matter, the conclusion reached is, that one ton of average sugar beets is worth as much for feeding purposes as 1½ tons of average mangel-wurzel."

The comparison between corn silage and sugar beets was further made by a new series of investigations during 1890.†

Comparison between potatoes and beets.

Very important experiments have been made under the auspices of the Iowa experiment station‡ with a view to determining the comparative value of *sugar beets* and *potatoes* in the production of *milk*, *cream* and *butter*. To facilitate understanding the Iowa data the results have been tabulated as follows:

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* Bulletin, No. 2, Ohio Agricultural Experiment Station, 1892.

† Bulletin, No. 5, Ohio Agricultural Experiment Station, 1890.

‡ Bulletin No. 17, Iowa Agricultural Experiment Station, 1892.

Results Obtained by Feeding a Short-horn Cow and a Holstein Heifer on Beets.

	Milk.	Cream.	Buttermilk.	Time of churning.	Butter.	Ration.	Market value of butter per lb.
	lbs.	lbs.	lbs.	min.	lbs.	lbs.	cents.
First churning........ (January 18th.)	80.5	13.5	9.0	12	3.75	50	20
Second churning...... (January 25th.)	84.0	10.75	8.0	11	3.75	20	18–20
Third churning ...... (February 22d.)	8.40	14.75	9.25	25	4.50	20	21–22
Average...........	82.8		8.75		4.0		20

From these figures we conclude that from 20.7 lbs. milk there was made 1 lb. butter worth 20 cents per lb.

Results Obtained by Feeding a Short-horn Cow and a Jersey Heifer on Potatoes.

	Milk.	Cream.	Buttermilk.	Time of churning.	Butter.	Ration.	Market value of butter per lb.
	lbs.	lbs.	lbs.	min.	lbs.	lbs.	cents.
First churning	54	10.2	6.5	15	3.0	40	20
Second churning.....	46	5.25	3.0	22	1.5	20	16 to 17
Third churning	34	5.75	2.75	20	2.2	10	18 to 19
Average..........	45		4.08		2.3		18.3

We conclude that from 19.5 lbs. milk there was made 1 lb. butter worth 18.3c. per lb.

From February 2nd to 22nd the cows fed on beets gave 1.056 lbs. milk, those on potatoes during same period 581 lbs. milk. If we admit the foregoing averages, there would be extracted 51 lbs. butter from beet milk worth $10.00, from the potato milk 30 lbs. butter worth $5.50, or $4.50 in favor of beets, during a period of 20 days. To these profits must be added the cream and buttermilk, which with beets is nearly double that obtained from potatoes.

It would be interesting to determine the comparative fertilizing value of the manure from cows fed upon potatoes and beets. One fact appears to us certain, that 50 lbs. beets at $4.00 per ton are always cheaper than 40 lbs. potatoes, even at the same market price, and admitting that the butter returns would be the same (?). Beet butter has its own characteristic color, and will keep for months, while potato butter has no keeping qualities and is colorless.

It has been concluded that high-grade butter cannot be made when cows eat more than 10 lbs. potatoes *per diem.* When cows are eating 20 lbs. beets *per diem* no coloring matter need be used and the resulting butter is of a superior quality and has a most excellent flavor while potato butter lacks flavor. These feeding experiments were conducted with considerable care, the ration being gradually increased, and then decreased. An important fact noticed was, that cows will continue to eat 50 lbs. beets with relish, but after a time refuse the 40 lbs. potatoes.

Other experiments.

Other experiments have been made to determine the value of potatoes and roots for fattening lambs.* The test was made with 36 lambs divided into 3 lots of 12 each. The three lots consumed about the same quantity of grain, hay and roots. The table herewith shows the result of these tests:

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* Bulletin No. 59, Minnesota Agri. Exp. Station, 1899.

COMPARATIVE RESULTS OBTAINED BY FEEDING LAMBS WITH POTATOES, BEETS AND MANGELS.

	Average weight at the beginning of test proper.	Average gain per lamb.	Food comsumed per lamb per day.	Cost of food per pound gain.	Total profit per lamb.
Lot 1, potatoes	50.6 lbs.	32.9 lbs.	3.52 lbs.	4.94 cents.	$0.86
Lot 2, mangel-wurzel	50.8 "	30.6 "	3.52 "	4.20 "	1.07
Lot 3, sugar-beets.........	50.6 "	34.6 "	3.57 "	3.78 "	1.24

These figures speak for themselves—with beets the average gain, cost and profit were greater than with either mangel-wurzels or potatoes.

In experiments made to determine the relative value of sugar beets for steers and sheep, it is interesting to note that "the lot fed on alfalfa and sugar beets returned a net profit, above a fair price for feed given, of $3.45 apiece, and the lot fed on alfalfa and grain a loss of $2.38 apiece." The sugar beets were valued at $3.50 per ton. Like experiments were made with sheep. The conclusion was that the lot fed hay and sugar beets during the second period gave better returns than those fed on hay alone.*

Experiments to determine the comparative feeding value of silage, sugar beets and mangels were made at the Pennsylvania experiment station, the result of which experiments is shown in the table herewith:

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* Bulletin No. 30, Wyoming Agri. Exp. Station, 1896.

COMPARATIVE FEEDING VALUE OF SILAGE, BEETS AND MANGELS FOR COWS.

	Milk.	Butter.	Solids. Not fat.
	lbs.	lbs.	lbs.
Lot 1, silage (2d period).........	141.3	9.0	12.1
Lot 2, sugar-beets (2d period)	152.4	7.7	13.3
Lot 3, mangel-wurzels (2d period).	116.0	6.4	10.4

These figures show that the milk production is in favor of beets. Considered as a whole, these figures appear to be slightly in favor of silage, the difference, however, being so slight that it need not be considered.*

In New York, Cornell University has made some interesting experiments to determine the effect of different rations in fattening lambs. In these, instead of sugar beets, mangolds were used. The lambs selected were thin in flesh and considered well adapted to the experiment. We notice in these results several important facts apparently overlooked.

The sheep were divided into four lots of three each. One lot did not have a ration suitable to its requirements, so the results obtained in that special case need not be considered. The fourth lot received no roots during the entire period of feeding, and the total protein was nearly the same as in the third lot. The increase of weight was 80.5 per cent. for second, 73 per cent. for third, and only 52.7 per cent. in fourth lot (without roots).

It is maintained that the nitrogenous food in the second case was the cause of the excessive gain; this may be true, but it certainly was not so in the third. The animal before fattening weighed 51.5 lbs., and five months afterward weighed 89 lbs., with a ration of mangolds, hay, corn, wheat, beans, etc., while with wheat bran, cotton-seed meal, corn and timothy hay (no roots), lambs weighing 54.7 lbs. in November weighed 83.59 lbs. in April.

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* Report Pennsylvania Agri. Exp. Station, 1896.

Another interesting fact is, that the cost of grain per 100 lbs. with roots was $6.03 to $6.36, while without roots it was $7.82. In the former cases the digestible nutrients were 363.9 lbs. and 383.2 lbs., while without roots only 351.4 lbs. were digested; the object was to feed all that would be readily eaten. A fact that we wish to emphasize especially is, that roots assist the digestion of other fodders, and force consumption, which is of considerable moment. The two lots fed with mangolds in their ration gave an increase of wool of 72 and 56 lbs. respectively, while without roots the wool weighed 46 lbs. As the protein in the last two cases was nearly the same, this result shows an increase of 10 lbs. wool in favor of mangolds.

Another experiment station of the country, with a view to determining within what limits siloed cossettes compare with forage beets when fed to milk cows, conducted a series of experiments, the result of which was that cows fed on forage beets gave 1137 quarts of milk containing 79 lbs. fat, while the residuum fed cows resulted in 1105 quarts of milk containing 75 lbs. fat. The difference is so slight that the results may be considered identical. The forage beet ration consisted of 72 lbs. beets, 8 lbs. clover hay, 6 lbs. chopped straw and 5 lbs. oil cake for 1000 lbs. live weight. The other ration consisted of 80 lbs. residuum cossettes, to which were added 9 lbs. chopped straw, 8 lbs. clover hay and 4 lbs. oil cake per 1000 lbs. live weight. Later experiments upon a very extended scale have demonstrated that the cossette feeding is more economical.

Feeding Sugar Beet Leaves and Tops.

Preliminary remarks.

The cultivation of sugar beets to be furnished to the factory for the extraction of sugar is not the only question to be considered by the farmer, for the simple reason that the resulting pulp or residue has an enormous value to the agricultural community. Besides the roots proper, one may harvest a large quantity of leaves and tops which without being of any commercial value are of great importance to the tiller. However, there are many farmers sufficiently blind to overlook the precious qualities of these portions of the plant, and allow them to remain and rot on the field without rendering other service than that of supplying a portion of certain mineral elements—representing plant food—which have been absorbed by the root during its development. The money value of these leaves when used as a fertilizer is certainly less than that which would be derived from feeding to cattle. Beet leaves and tops contain, it is true, a certain amount of salts which are useful to the soil, but on the other hand many of these mineral substances can be more advantageously utilized by feeding the leaves to cattle and collecting the manure; their fertilizing properties are not subsequently lost by the passage through the animal's body and during the interval the stock has been benefited by receiving a good wholesome green fodder at the very period of the year when it is most relished and is eaten with avidity. A difficulty as regards this question arises here: Experience shows that the best results are obtained by feeding siloed beet leaves during early spring. Experience also shows that barn-yard manure must not be applied to lands during the season of planting.

If the tiller is anxious to return to the soil the salts the manure contains, he must cultivate that year some other crop than beets upon it; otherwise the resulting roots would very probably be refused at the factory owing to their low coefficient of purity. When beet-sugar factories are located near populous centers, beet leaves may render excellent service for dairy cows. Under such circumstances farmers should depend upon their own fertilizers rather than on those from cities, which are mainly made up of organic matter.

Composition of leaves and tops.

Chemical analysis of this residuum demonstrates that the use of beet leaves, etc., may become a vital question during those years when the beet harvest has been unsatisfactory.

While such analyses vary under different conditions, it is very important to give what may be considered an average. Their composition, according to Dr. Herzfeld, is as follows:

AVERAGE COMPOSITION OF BEET LEAVES AND TOPS.

	Leaves.	Tops.	Entire beet.
Water	89.05	80.10	81.5
Ash	2.20*	5.65	0.7
Raw protein	2.80	1.99	1.0
Fatty substances	0.45	0.24	0.1
Fibre	——	1.83	1.3
Nitrogen free extract	5.50	10.00	15.4

From this one concludes that between the tops and the entire beet there is a very great difference. The necks have double the nutritive value of the leaves. However, when fed to animals, it is the custom to combine the leaves and tops.

A glance at these figures shows that the tops contain more salts than the leaves; in raw protein the leaves have a slight advantage; in pure protein the tops contain 1.25 per cent. while the leaves contain only 0.75 per cent. The tops, weight for weight, contain nearly twice as much of nitrogenous constituents as are possessed by the leaves.

Beet leaf stripping.

As soon as farmers of certain sections commence to realize the value of beet leaves for cattle-feeding they do not appear to be able to resist the temptation of stripping the beets of their foliage before the harvesting period commences, and this practice means a considerable reduction in the ultimate sugar percentage of the roots, with an increase of the saline percentage. The necks of the beet become more and more elongated. Nature in her effort to restore the mutilation sends out new leaves, which means a temporary reduction in the sugar percentage of the beet, and this is never replaced, notwithstanding the fact that the young foliage performs a certain amount of sugar elaboration. When the harvesting period arrives the tops must be removed from the beets, and the larger they are the smaller will become the ultimate yield of sugar beets per acre; furthermore, the farmer receives a decreased price for his beets, for they not only contain less sugar, but the juices are less pure than they would have been had the leaf stripping been prohibited. When farmers grow beets for cattle-feeding there can be no objection to stripping.

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* According to Wolf's analysis, the ash percentage is 1.5, of which 0.4 is potassa, 0.2 soda, 0.3 lime, 0.17 magnesia, 0.07 phosphoric acid, 0.08 sulphuric acid, 0.16 silicic acid, and 0.13 chlorin.

Early feeding and mistakes made.

Small farmers are necessarily obliged to feed the leaves immediately, and under such circumstances there is a great waste of material. They are pulled from the cribs as eaten by the live stock and certain portions fall on the ground, are trod upon and are thus lost. This is why it is more economical to chop up the leaves before the early feeding.

Many farmers allow sheep to run over their fields and eat the leaves during their passage. Under all circumstances such customs should be prohibited, as large quantities of leaves are necessarily trod under and are thus destroyed, which in reality means a waste as far as their nutrient value is concerned. Furthermore, it is simply folly to allow freedom to sheep, etc., at that period of the year when there is always danger of rain. Another fact not to be forgotten is that sheep manure is not considered a desirable fertilizer for sugar beets; but this would evidently be of no consequence if a suitable rotation of crops was maintained.

As a general thing as soon as the beet harvest commences residuum feeding is resorted to, but for a farmer who has a considerable area devoted to beets it is necessary to adopt some system of feeding which will ultimately become quite an economy when green forages are scarce.

Harvesting the crop of beet leaves and tops.

It is urgent in most cases in harvesting the beets either to form piles of the roots on one hand and the leaves on the other, or to alternate rows of leaves and roots, or again to form piles of the beets and use the leaves as a cover. When the piles are small the practical results obtained are more satisfactory, as the leaves then are left on the ground and are subsequently collected.

An average crop is about 12,000 kilograms of leaves and tops to the hectare (4.8 tons to the acre), which may be composed as follows: 25 per cent. for the tops and 75 per cent. for the leaves. If one makes allowance for the cost of conveyance of the leaves and tops to the center of utilization, it will be seen that the losses are considerable when not promptly utilized, especially in cases where they are considered as having fertilizing value. Their nourishing value means 1,600 (1,408 lbs. to the acre) kilograms of dry substance to the hectare, of which 260 kilograms (228 lbs. to the acre) are albuminoids. Their value, which is frequently only moderately appreciated, is in reality such that it should not be neglected, and if added to the price paid for the beet at the factory one will be surprised to see at what cost these roots could be furnished to the manufacturer by the farmer; notwithstanding this fact, many tillers will not take the matter into consideration.

In 1873 in estimates of the possible money cost of working a beet-sugar factory the beet leaves to be harvested were frequently taken into consideration. The idea then was to utilize them in a manner that has never since been realized—they were to form a substitute for tobacco.

Beet leaf keeping.

The only rational utilization of beet leaves which is generally applied at the present day, consists in keeping them as a sort of sour fodder. The first experiments at beet leaf keeping that we know of were made in 1852 at Thiede, but these were not successful, for the simple reason that air was allowed to enter the silos, which is very objectionable, as we shall see later on. Since then many modes have been proposed which were intended to obviate existing faults, but none of these systems proved successful. The method which is now generally adopted consists in allowing the leaves to remain on the field for three or four days, after which period they are soft and no longer possess the rigidity which would otherwise have prevented their satisfactory settling in the silos. Comparative experiments made by Muller show just to what extent the method of placing in silos exerts an influence. In the one case the leaves in a more or less wilted condition were placed in a silo in layers and well pressed and subsequently covered with three feet of earth; in the other the ordinary mode of siloing was adopted.

Composition of Beet Leaves Siloed in Two Ways.

	Layers of Leaves.	Regular Siloing.
Water	74.95	79.67
Protein substances	2.90	2.65
Raw fatty substances	0.65	0.54
Extractable substances	8.69	7.59
Raw fibre	2.79	3.11
Mineral substances	9.66	0.14
Lactic acid	0.33	6.31

Furthermore, these leaves during the wilting lose part of the water, which may be considered an advantage. They should be well shaken as a preliminary operation, with a view to getting rid of any adhering earth, and then compressed into silos dug out of the ground, cemented or not, as the case may be. The silos are usually about six feet in depth; their length is variable and may suit the ideas of each farmer. The width of four or five feet appears satisfactory; the bottom should have a slight slant, say ⅓ inch per yard and suitable means for drainage. The method of filling, and also the most desirable condition of the leaves before being siloed, remain open questions.

There are various modes of compressing the leaves in the silos, one of which consists of allowing a cart with wide tires to pass over each successive layer. This operation is repeated several times. However, precaution should be taken that the wheels of the wagon do not pass over in the same rut each time. In such cases the silos have a width equal to twice the spacing between the wheels of the cart. Excessive pressure is not desirable in beet-leaf preservation. Experiments show that leaves partially lose their nourishing value when submitted to great pressure. The custom of treading down the upper surface should be abandoned. The leaves are piled up several feet above upper border of the silo. These soon settle and more leaves are thrown on top; when the surface remains constant a conical pile of leaves forms the top; this is covered with a layer of earth, the thickness of which depends upon the ambient temperature. Care must be taken that cracks be well filled, so as to keep out air.

Transformation in silos and losses.

After a few days the mass becomes heated, and there follows a lactic fermentation which when completed leaves the mass in a brown colored condition. It may remain in a perfect state of preservation during a very long period, lasting for several years—three or more. The fermentation in question means a considerable softening of the leaves and a reduction in the volume of the exterior portion. The mass settles, and the volume is reduced by one-third and frequently 50 per cent., the loss of nitrogen being 30 per cent., and it is at this time that open crevices are noticeable in the earth covering, through which there is danger of air penetrating. Under these circumstances there would follow all sorts of secondary reactions very favorable to the existence of micro-organisms, the combined action of which would cause putrefaction. Under all circumstances, it is advisable to carefully close these openings as soon as they are visible. The upper stratum always comes more or less in contact with the air, and is consequently the first to show signs of decay or organic changes of the residuum being kept. It necessarily follows that these transformations mean a money loss to all interested.

A German analysis* of leaves siloed for six months showed that they contained 0.136 per cent. oxalic acid soluble in water and 0.46 per cent. insoluble in water—possibly in the form of a calcic oxalate.

Stutzer gives the following analysis of siloed beet leaves:

	Per cent.			Per cent.
Water	69.8	The raw protein contained	Amides	0.4
Mineral substances	15.9		Non-digestible nitric substances	1.7
Raw protein	2.2			
Cellulose	4.3			
Non-nitrogenous	6.4			
Fatty substances	1.4			

The excessive mineral percentage was explained by the impurities possibly introduced by the leaves from having been in contact with earth.

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*No analysis should be made of siloed leaves until cleaned and free from the earth collected from the side of silos.

It has been proposed, in order to obviate the losses of these protein substances, to have a cemented bottom in the silos so as to retain the liquid in question; but experience has shown that there follows no increase in the total nutritive value of the final product; and furthermore its palatability is very much lessened. In order to increase the conservation of siloed leaves it is desirable to add one per cent. of ordinary salt.

It may happen that the mass becomes excessively heated, and instead of lactic acid there will be formed acetic acid, resulting in an acetic fermentation. This very materially diminishes the nutritious value of the leaves that are to be kept. Efforts have been made to hasten the lactic fermentation with the view of obviating this difficulty. To produce lactic acid the leaves are moistened during siloing with sour milk, but this has not given the results hoped for.

Faulty siloing. Under certain circumstances, which we regret to say are of very frequent occurrence, the siloing has been very badly done, and the exterior leaves are rotten. These may be removed by a spade or any other implement. Regarding this question it is well to note that under all circumstances there is necessarily a certain decomposition of the upper surface of the product being siloed, and it does not necessarily follow that the person in charge is responsible for the surface alterations which always occur, do what one may; but what we have réference to is an excessive putrefaction, such as is frequently seen in some of our western farms where efforts have been made at siloing either leaves or cossettes. Any putrefaction of more than one foot below the surface is extremely faulty. Two or three inches from the surface may be said to be the limit.

Leaves and other substances in silo. It seldom occurs that beet leaves are siloed without the addition of some foreign material, the object of which is extremely variable. Upon general principles these leaves are kept in conjunction with other forages in order to obtain a compact mass into which air penetrates with difficulty. Under these circumstances there is very much less danger of putrefaction, and this siloed material, which is of great value to the farmer, lasts without undergoing the slightest change during a period of years.

It is considered desirable, according to Herzfeld, to carry out

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the siloing with alternate layers of tops, leaves and residuum cossettes.

Under all circumstances the tops should never be separately siloed, otherwise they would lose too much of their nutritive value and would rot. Upon general principles it is well to alternate with the leaves a certain number of layers of straw with a view to absorbing the excess of moisture thrown off by the leaves and in this manner the soil is prevented from absorbing it. This is the usual practice.

If during the siloing a certain amount of salt is added, an allowance must be made for this fact during feeding so that an excess of this condiment will not be administered.

In certain parts of Germany visited by the writer the beet leaf siloing is done in silos about 6 feet deep with rounded corners, the bottom slanting slightly. Upon it there is placed a certain layer of straw, after which the leaves are placed to a depth of about 5 inches, and the mass is compressed by simply stamping upon it. Then there are added about 7 lbs. of salt per ton of leaves, over which is placed a 4-inch layer of straw, followed by another 5-inch layer of leaves, etc., until the mass is 3 to 4 feet above the level of the ground.

Many years since Grouven made a series of experiments in siloing leaves, and the combination giving the best results consisted of 2,000 lbs. of leaves, to which were added 150 lbs. straw and 500 lbs. beet tops. After 6 months' keeping of the product, the analysis showed that the addition of straw had a tendency to retain the juice of the leaves, regulating at the same time the fermentation.

First of all the sugar contained in the tops disappears. It is found from experiments that when the tops are siloed with their leaves they had better be well chopped up. The extractive substances of the tops and a portion of the cellulose of the leaves undergo an acid fermentation and are thus transformed into many complicated constituents, the nutritious value of which is very questionable. Finally, the proteid substances are transformed into amides, the nutritive power of which is very much less than albumin proper. A large portion of the disappearing nutritive substances is changed into certain compounds that are found in the liquid which separates or runs off from the leaves.

Soft leaf fodder. Postelt works in the following way in order to obtain a soft fodder, as he calls it. Upon general principles the idea is to bring about as rapidly as possible a temperature of at least 25 degrees C. [77° F.] in the midst of the leaves, and furthermore to maintain this temperature. The wilted leaves heat more rapidly, due to the fact that they contain less water. They are thrown into the vat in which a proportionate amount of chopped straw is combined. Furthermore a certain quantity of this substance is added without attempting to compress the same. After intervals of two or three days the temperature rises to 50 degrees C. [122° F.]. Then there follows a daily addition of beet leaves so that the thermometer introduced into the mass of the leaves will always indicate the same temperature. This heating may be explained by an oxidation through the influence of the oxygen of the air which is retarded by a new pressure of the leaves forced layer by layer one over the other. Under these circumstances naturally considerable air is imprisoned therein. It has been suggested that a certain amount of lattice work be arranged around the silos so that the mass of leaves can be raised, say nine feet, above the level of the ground, and covered with moist earth. Precautions should be taken to separate the leaves from the earth at the bottom of silos with a layer of chopped straw. It is further recommended under no circumstance to add leaves to the silos when the temperature is too high.

Beet leaf washing. The Lehmann & Maercker method for soured leaves has many advantages. These well known agronomists find that the washing of leaves, when they have been properly siloed, effects the elimination of dirt-like substances, which when allowed to remain will, under all circumstances, give to animals a distaste for what they are given to eat, as the sandy particles get between their teeth and they become discouraged and reject this food later on.

Lehmann washes the leaves in a wired basket in a suitable tank filled with water. From his personal observation he has concluded that under these circumstances leaves lose 1.3 per cent. of their organic substances, 0.5 of protein, 0.12 fatty substances, 4.53 of mineral substances, 0.09 of celluose, and 0.68

of non-nitrogenous extractive substances, all of which are calculated upon the basis of soured leaves. Observations show that upon an average the loss is 8.03 per cent. of the absolute quantity of organic substances.

Maercker declares that the losses, owing to washing, are very much greater and are nearly 25.05 per cent. of the total organic substance. There is lost, according to this authority, 75 per cent. of ether-extractable substances, and he declares that under these circumstances it is very advantageous, as these constituents are worthless. It is now generally admitted that washed leaves have the same nutritive value as forage beets.

Acidulated beet leaves.

The Mehay mode that gained considerable favor over thirty years ago, had for a general starting-point a cooking of the leaves in water containing a small percentage of hydrochloric acid. The operation was conducted in the following manner: "A special receptacle of about 530 gallons capacity, in which the boiling was done, was half filled with water, to which were added about 3 quarts of hydrochloric acid at 22° Bé. This was well stirred so as to assure a perfect combination of the water and acid, and after the boiling had lasted for a few minutes 1000 lbs. of beet leaves with their tops were added just as they were collected from the field subsequent to the sugar-beet harvesting. The receptacle at first is too small to contain the leaves in question, but as the boiling continues they settle and may be readily kept beneath the surface of the acidulated water. The boiling ceases after 15 minutes, when the leaves are removed with wooden pitchforks and allowed to drain for a short period, the liquor running off being returned to the boiler. Special stress was placed upon the importance of collecting the leaves upon the field as soon as possible, thus preventing any possible alteration they might undergo, as during such organic changes they become possessed of a characteristic odor which even the boiling and acid treatment do not overcome.

After a certain number of repeated boilings there is deposited at the bottom of the receptacle a certain quantity of dirt, etc.; hence it was customary to allow it to settle entirely and then decant. It was noticed that the earth always neutralized a certain percentage of the acid used, and hence it was important to make allowance for this loss. It was argued that during this acid treatment the alkalies, such as potassa and soda, became potassic and sodic chlorids, and took the place of the organic acids. Far from reducing the nutritive value of the product, they on the contrary rather increased the nourishing properties of the leaves treated. The leaves thus prepared were placed in special silos with false bottoms, from which the water draining from the mass could be drawn off. It was proposed to subsequently distil the liquor with the view to alcohol production. The heating of the receptacle could be done upon an open fire with steam coils, etc., but under all circumstances the coils used should be copper so as to diminish the chances of their being attacked by the acid. Later modifications of this mode resulted in using wooden vats with steam coils. The cooking of beet leaves became very popular in certain parts of the North of France and Belgium; but at first no acid was used nor were such leaves siloed. It was found later on, when introducing the Mehay mode upon an extended scale, that great advantages were derived from chopping the leaves up into small pieces, which greatly facilitated the action of the acids used, especially in cases where boiling was done away with. It was noticed that a certain interval was always needed by the cold water mode before the acid had completely penetrated the entire texture of the leaves treated, and under no circumstances should they be fed to cattle before assuming the same appearance as to texture as leaves that had been boiled. However, by the cooking mode two men can handle 3 tons of leaves per diem, which after the treatment are reduced to 2.0 tons. At that time this preparation cost, including fuel, interest on investment, etc., about $1.20 per ton of leaves, and was worth, it was then declared, at least $4 per ton.

Beet leaf drying. Müller has published a calculation showing that, practically and theoretically, there is a special advantage in drying beet leaves with a view to their transformation into dry fodder. Under these circumstances it is possible to obtain a combination of superior money value when considered on a basis of 100 lbs. of material fed. It is not found desirable to dry the leaves in any special appliance. It is far better from an economical standpoint to avail one's self of the fine weather and sunshine that frequently occurs in the autumn. Under these conditions the leaves will be semi-dried. An example may be cited in which the tops lost 80 per cent. of their weight in eight days; the leaves, strictly speaking, lose 33 per cent. Rain has not as unfavorable an effect upon the desiccation as one might suppose, as the water that is deposited upon the leaves in the form of dew readily runs off and is rapidly evaporated when brought into contact with the wind or any mechanical influence. During ordinary weather the leaves lose in five or six days 50 per cent. of their moisture, and if 25 per cent. more is evaporated a commodity is obtained that will be possessed of all the requisites for easy keeping.

Air desiccation is apparently not feasible at the time of year when the sun has very little evaporating force; but it is important not to overlook the fact that there are many other industries that have the same difficulties to contend with, and overcome them successfully.

Crummer dryer.

Authorities in some cases have suggested that the "Crummer dryer" may possess all the essential qualifications. The leaves and tops undergo a sort of preliminary chopping and pressing in the air, so as to withdraw or extract an additional amount of moisture; and this operation is then followed by the action of a series of compressing drums in which circulates steam at various pressures. A point that is essential to bear in mind is that under no circumstance should the pressure of steam be the same in each drum, but on the contrary it is desirable to gradually increase it until reaching the limit of the desiccation in view. The dry leaves thus obtained have excellent keeping qualities, will not mildew, and have a good healthy appearance.

Buttner and Meyer dryer.

Buttner and Meyer by their method of drying resort to a preliminary desiccation by the elimination of a large proportion of the water contained in the cells of the leaves. They cut the leaves into strips in special machines, which are in reality not special, as they are simply those which are used to chop beets. The leaves are then forced through a spiral where they are submitted to the action of steam. Under the influence of this increased temperature the cells of the greater portion of the leaves burst open and the liquid they contain is liberated. After their passage through suitable presses the water percentage has been considerably reduced, and some authorities maintain that this reduction reaches 40 per cent.

The leaves, having thus undergone this preliminary water-elimination, are dried in special furnaces of the Buttner and Meyer type, which will be described later on. The leaves are then perfectly dry, with the exception, however, of a few small particles that are rather too large to have undergone a perfect desiccation during such a limited period.

In order to prevent these slices or pieces from being the source of a future infection and possible complications when considered from a fermenting standpoint (we refer to microorganisms that may possibly be generated and which would necessarily result in the putrefaction of the material under consideration), the particles being treated pass through a metallic gauze acting as a filtering medium, and are subsequently run through a special dryer.

On a particular farm visited by the writer, where the Buttner and Meyer method has been practically introduced, it has been possible to gather per hectare 3,500 kilograms of dried leaves [about 3,000 lbs. per acre], which, according to Maercker, have a commercial value of 9 marks per 100 kilogs. [say $1 per 100 lbs. or $22 a ton], which means 315 marks to the hectare [$31.50 per acre]. The same leaves when green are worth only 60 marks [$6 per acre]. The desiccation costs 2 marks per 100 kilogs. [24 cents per 100 lbs.], which in other words means 70 marks for the total dried leaves obtained from a hectare [$7 per acre]. The carting may be put down at 40 to 50 marks per hectare [$4 to $5 per acre]. There remains consequently a net profit of 315–180, or 135 marks per hectare [or about $13.50 per acre]. The installation of a plant for this special drying, etc., is not to be altogether recommended, owing to the cost of the transportation from the beet fields. According to Runkhe, the installation necessary for 125 hectares [300 acres] may be estimated at 20,000 marks [$5,000].

Vibrans declares that there is a decided objection to this method, owing to the fact that the preliminary pressing of the leaves in the Klusemann apparatus increases the dry matter from 7 to 30 or 40 per cent., which means that there has been pressed out 75 to 80 per cent. of the total liquid.

Unfortunately the water thus separated is not only water, but contains also a considerable percentage of dry substances. Happily these losses are not so heavy as might be supposed, as the original percentage of dry matter is higher than 7 per cent.; it is at least 10 per cent., and if the leaves during the period they remain in the field lose a certain percentage of this moisture, the dry substance they may contain is not less than 15 per cent., which leaves only 50 to 60 per cent. of the final liquid to be eliminated.

Wusterhagen dryer.

Wusterhagen has given the question of beet-leaf keeping and drying considerable attention, and his records upon the subject are worth noting. He declares that when leaves are to be fed to cattle they should always undergo certain preliminary preparations with a view to diminishing the percentage of oxalic acid.

Many modes for beet-leaf keeping have been suggested and experimented with. One of the recent German patents declares that in the question of beet-leaf keeping there are five facts that must be taken into consideration: 1st. Cleaning, with the object of getting rid of the sand, dirt, small stones, etc. 2d. Reduction of the toxic percentage of oxalic acid of the leaves. 3d. Retaining the saccharine substance of the tops and leaves. 4th. Decrease of the total volume of the mass. 5th. Complete and thorough drying with a view to perfect keeping. The efforts of M. Wusterhagen were to carry out these essentials to the letter. Upon general principles we may admit that the green leaves retain 10 to 20 per cent. sand, which offers some difficulty in complete laboratory analysis. While it has been recommended to wash the beet leaves, the idea does not appear to have much practical value. The sand collects in the tops during the washing and must be subsequently removed, which means, in practice, an additional expense. M. Wusterhagen says he allows the leaves to undergo a preliminary wilting upon the ground after the beets have been harvested, and this drying is continued in a current of hot air. The leaves thus dried are placed in a revolving drum in which the sand, etc., is separated through a well-arranged sieve, and this work may be very thoroughly done even during drying. Attention is called to the fact that in soil or sun-drying, the dew and rain bring about a slow decomposition of the oxalic acid. This fact is new and was unknown several years since; if true, it has a more than secondary importance. At first sight, it would seem impossible to decrease the oxalic acid and at the same time retain the total sugar in the tops and leaves, as oxalic acid needs for its entire decomposition a high temperature, which would destroy the sugar. Just why during sun-drying the oxalic acid should decrease has never been satisfactorily explained. Is the reduction due to an oxidation or the action of some micro-organism? The drying means a considerable loss of oxalic acid. Before desiccation the leaves contained 2.39 per cent. of this acid and after the hot-air treatment it fell to 0.60 per cent. The average for all the samples examined during one week was 0.45 per cent., while the analysis of a sample of the previous year showed only 0.35 per cent. of oxalic acid. Under these circumstances there can be no possible objection to feeding these dried leaves to cattle in their regular daily ration. On the other hand, when the green leaves are fed there are great risks, for the simple reason that the acid percentage of the dry matter frequently reaches 5.9.

When leaves are submitted to a very high temperature, as is suggested by Maercker, there is always some danger of bringing about an alteration in the sugar which is not desirable; hence the advisability of never exceeding a certain limit, and this is controlled by a current of cool air and the addition of some fresh substance to the mass. Both Drs. Zelber and Maercker declared that by the Wusterhagen mode there is no decomposition of the sugar. The operation of drying offers certain difficulties in view of the fact that one has varying elements to contend with, and these are all of very different natures. For example, the tops have an entirely different structure from the leaves, and in the latter the special delicate botanical formation must be taken into consideration. If there existed simply a regular, uniform heating, one portion would be entirely burned while the other would be only semi-dried. Long observations had demonstrated that the best mode is to begin with a systematic cleaning, then an air reduction in weight followed by drying. The tops remain upon the ground for several weeks; then they are put into small piles where the wilting continues, after which they are taken to the hot air dryer. By this treatment the oxalic acid is almost entirely destroyed, while the sugar contained in the tops has undergone very little transformation. The drying of the leaves and tops is then continued at a lower temperature, so that there can be no possible danger of caramelization, a special system for regulating the temperature of the dryer being used. The reduction in weight of the tops and leaves always means a considerable loss during sifting of the dust, impurities, etc. At the start 88 per cent. of substance to be dried diminishes at least 20 to 30 per cent. in weight during the air-drying or wilting. The artificial drying means 30 to 48 additional percentage. The leaves finally retain about 15 per cent. moisture. Beet leaf drying has already obtained considerable proportions.

According to Petry & Hecking, who have introduced the Wusterhagen mode upon several farms, these dried leaves will keep for at least two years under ordinary conditions, notwithstanding the fact that they show certain hygrometric powers. A sample containing 20 per cent. of water did not mildew even after a long period of keeping. They declare that this keeping power is due to their sugar percentage.

Proebent's experiments in beet leaf drying have shown that the operation costs about 50 cents for 220 lbs. dry matter. In Belgium the profits are about one cent a pound. From a hectare (2.5 acres) there is collected about 3 tons of dry substance, which is worth at least $30 in its dried state.

Vibrans cannot understand how the technical authorities can possibly attempt to extract the water from a substance which contains already less moisture than do pressed diffusion cossettes, and if these can be dried under remunerative conditions certainly beet leaves could be desiccated under very much better circumstances, if, instead of pressing the product, some practical method was devised for bringing the dryers to the leaves as found upon the field.

The idea does not seem in many respects to be practicable; it is, however, very advantageous when sugar factories cultivate the beets themselves. Under these conditions the roots are farmed in the vicinity of the factory; but when it comes to the transportation of leaves for a distance of 2½ miles at a period when all means of traction are more expensive, such a system would be excessively costly. It would be necessary that the plant should consist of an apparatus for cutting the leaves, for the drying in a special furnace, and a movable engine that would carry the appliance where it was required. The combined machinery should be placed under a light movable roof.

The desiccation of leaves has the great advantage of doing away with the moisture that may have been produced during siloing, under which circumstances they would more surely approach the feeding value of hay. Furthermore the product would be vastly more healthy and would not be possessed of any of the laxative properties of fresh leaves. Moreover the amount of oxalic acid they contain is considerably reduced. Already the beet leaves that have remained on the field during an interval of a week or ten days after the harvesting of the beets, lose a considerable proportion of their oxalic acid. This statement, previously mentioned, is absolutely true. Apparently there has been produced a sort of fermentation which reduces the oxalic acid. However, this decrease may be the outcome of a continuation of some physiological action of a substance contained in the leaves after they are separated from the main body of the root, and this reduction increases during desiccation. There seems to be every reason to believe that there is great truth in this assertion, for the analysis, as given by Vibrans a well-known chemist, substantiates his views. The dry leaves contain 0.03 to 0.05 per cent. of oxalic acid, and 15 to 20 per cent. of water, 5 per cent. albumen and 12 per cent. sugar. Buttner and Meyer allow only 0.23 per cent. of oxalic acid. On the other hand it is true that in their method there is no explanation of the loss of oxalic acid during the pressing of leaves in the Klusemann press.

Beet leaf feeding. There is no example to be given of any serious complication arising from the special beet leaf feeding. It is well to remember that in these scientific experiments the results obtained show data that can be absolutely relied upon, and those interested in cattle feeding can adopt the given principles without the slightest hesitation.

However, in the early experiments that were made in these new efforts at the utilization of products either from the beet sugar factory direct, or from the residuum of factories, there have always been certain unknown factors to contend with, but as matters now stand and as investigations have been made by the leading experimental stations of continental Europe, it is not to be presumed that any practical error has been committed.

Attention has been called to the experiments of Priester in the "Milchzeitung," the well-known organ of Germany devoted to this specialty. In this publication it is declared that when cows have been exclusively fed with leaves and without the intensive additional use of another forage, no results other than those which have been extremely satisfactory have ever been recorded. The quantity of milk has increased, and furthermore in cases of working oxen the amount of traction obtained after a given interval has been quite equal to that which has hitherto been realized by many of the complicated formulæ advanced by well-known specialists.

Objections to beet-leaf feeding.

The introduction of beet leaves as a forage, and especially siloed leaves, has met with endless objections among farmers. It has always been declared among tillers that there is danger of lowering the general health of the animals by excessive beet-leaf eating, owing to the purgative effect of the residuum. This objection is in a measure correct; however, at the present day, these objections have, without doubt, been very materially overcome. To reply to many erroneous assertions about beet leaves in cattle feeding would be a waste of time; suffice it to say, it is much to be regretted that several agricultural journals of the country should have printed articles written by persons who certainly have had little or no experience in the subjects they were discussing. "Beet leaves fill up cattle; * * * they produce a bad effect upon the kidneys owing to their containing an excess of alkalies, etc., etc.," are only a few of the theories advanced. It has been pointed out that cows, when fed with beet leaves during the period of gestation, would bring dead calves into the world, and their milk and butter would be of an inferior quality, to say nothing of the resulting diarrhoea. Practical experience has shown the absolute absurdity of such theories. However, no one can deny that during the first stages of beet-leaf feeding there is always certain evidence of diarrhoea, but this laxation of the intestinal tubes is assuredly only temporary, lasting, we will say, a few weeks, and no ill effects have been known to follow, provided certain precautionary measures are taken.

It is claimed that soured leaves give sour milk, but the fact of the matter is that it would require a very delicate palate to distinguish between the milk of cows fed with hay and that which has resulted from beet-leaf feeding. The observations of Von Schmidt are not very reliable, for he claims that such milk is in no way suited for the manufacture of cheese. It has been noticed upon several occasions that butter produced from milk obtained from cows fed on beet leaves is hard, but even if such be the case this difficulty may be readily overcome. It is sufficient to give to the cow or live stock being fed a certain amount of oil cake in order to reduce the butter to any condition of softness that the locality may call for. It is, however, recommended that, when one wishes to give to live stock turnip cake, the quantity introduced into the ration should not exceed one kilogram per diem if it is desirable that the butter shall not have imparted to it a turnip flavor. The fault found by Grouven with beet-leaf feeding is that this residuum does not contain sufficient phosphoric acid. Such assertions do not appear to be endorsed by modern science, as Stoklasa has shown that a considerable quantity of this chemical is formed in the leaves during their early development. However, very little is shown to exist, and oil cake had better be added.

Oxalic acid—its influence.

It has further been pointed out that beet leaves are actually possessed of certain toxic influences due to the oxalic acid they contain. Before refuting such assertions it is interesting to call attention to Hertzfeld's experiments, which demonstrate that oxalic acid, far from being the result of the decomposition of the leaves, in reality disappears in notable proportions during the siloing, owing to the action of a certain mushroom which, according to Keller, decomposes the oxalates during their keeping. Zuntz has demonstrated by his experiments that oxalic acid has without doubt a toxic action; oxalates, on the contrary, possess this action to a very much less extent. On the other hand, beet leaves that contain oxalic acid in the proportion from 5 per cent. to 10 per cent. of their dry substances, contain it mainly in the form of oxalate of lime, which is not dissolved in the first stomach of ruminants, nor in the lower portion of the intestinal canal. However, it may be digested in the rennet, and if a certain amount of lime is present there can be no possible danger of toxication. It is proposed, under these circumstances, to give at the same time with a regular ration of leaves, 0.05 to 1 per cent. of lime as chalk, carbonatation scums or in some other form. The need of lime is not urgent during the first stages of digestion as the oxalic acid is neutralized by the lime taken from the bony tissues of the body.

The body of man, and also that of animals, has the peculiar property, as previously pointed out, of yielding to the organism little by little the components requisite to sustain life during periods of excessive work or abnormal strain. This expenditure or absorption of lime, according to Zuntz, demonstrates that it is impossible to feed live stock indefinitely with green leaves without the addition of this calcic salt, as there would necessarily follow a reduction in the bony tissues, resulting in dangers of a very serious nature as far as the health of the animals being fed is concerned.

The addition of lime to the forage in the form of chalk or carbonatation scums, reduces very materially, if not to a minimum, the deleterious actions referred to above.

Gaspari arrives at the same conclusion as Zuntz and declares that this forage, which contains only a small quantity of oxalic acid, far from being deleterious, plays on the contrary an important role in stimulating the appetite of the animals fed. It is further recommended by this authority that special precautions, such as those first mentioned, be taken with the view of preventing accidents that may occur through this mode of feeding.

Zuntz has made a series of experiments on sheep and has found that they are not affected by oxalic acid. He believes that their pouch or second stomach must necessarily contain a substance that effects a fermentation and completely destroys the oxalic acid with which it comes in contact. He recommends that animals receive increasing quantities of this forage, and under no circumstances should the maximum be reached at the early stages of feeding. This idea is in striking accord with all accepted rules and theories of stock feeding in general, as advanced by the leading authorities.

Conclusions respecting beet-leaf feeding.

Under all circumstances, as is generally admitted by those who have given dried leaves a thorough trial, the results obtained with them are superior to fresh or sour leaves from many points of view, not only as regards their nutritive equivalents, but also their keeping qualities.

A fact never to be forgotten is that the leaves are not eaten by cattle with avidity at first. They must first become accustomed to the new diet, as to many other condiments. However, a change occurs after a few days, and then live stock in general appear to like this fodder and to eat the same with an unexpected relish. It is only under very exceptional circumstances that a cow, or whatever animal is fed upon this waste, will refuse it, and if this proves to be the case one may be assured that there is some organic trouble existing and that the animal is not in its normal physical condition, and should be medically treated.

In Germany excellent results have been obtained when feeding about 30 lbs. beet leaves per diem per head. As this has been practiced for many years, it seems curious that a practical farmer should not discover whether the fodder he used was profitable or not. Hundreds of other examples could be cited. A fact too frequently overlooked is, that when a sudden change of diet is made for dairying cows, there always follows a decrease in milk production, and it remains to be determined whether this is due to the fodder or to the new "regimen."

Sufficient has been said in the foregoing to point to a question of great agricultural importance in the future development of the beet-sugar industry in the United States. When we consider that the weight of leaves is nearly equal to one-half the weight of the beets, it is easy to estimate the enormous volume of cheap fodder farmers are to have at their disposal.

Relation of beet to leaf composition.

Corenwinder, not many years since, demonstrated that a luxuriant foliage always indicated a high sugar percentage. According to Deherain, beets testing 16 per cent. sugar will have leaves weighing 60 lbs. per 100 lbs. roots, while leaves from roots containing 11 per cent. sugar would not weigh 30 lbs.

The quality of the beets has an important influence on the saline composition of leaves; the richer the beet, the higher the percentage of salts in leaves. The saline elements taken from the soil and contained in leaves are for beets testing 15 per cent. sugar, about as follows:

Potassa 5.30 to 5.7, soda 1.45 to 1.55, lime 1.40 to 1.55, magnesia 1.18 to 1.30, chlorin 1.44 to 1.65, sulphuric acid 0.64 to 0.65, silica 0.35 to 0.64, phosphoric acid 1.18 to 1.20, various 0.78 to 0.85, in a total of 14. Strange as it may seem, these show 14 lbs. of important substance, taken from the soil by leaves, for every 100 lbs. sugar contained in the roots.

Grouven also says that 100 lbs. of fermented leaves are equal for feeding purposes to 150 lbs. of fresh leaves, and equal to about 20 lbs. of the very best fodder.

Attention should be called to some experiments in which cows were fed upon beet leaves and gave milk, from 24 lbs. of which there was extracted 1 lb. butter. With the same cows, but without leaves, 28 lbs. of milk were necessary to produce 1 lb. of butter. This would show beyond cavil, that beet leaves are favorable to milk production. Wild's experiments demonstrate that very satisfactory results may be obtained by feeding beet leaves and straw to sheep; he found that 57 per cent. of total organic substances were digested. Maercker made the following experiment in feeding beet leaves and necks to sheep. There were two series of ten animals each, one series receiving 50 kilos of beet leaves and the other 40 kilos of residuum cossettes, to which was added the desired percentage of nitric elements, etc. From a money point of view, the results obtained were in favor of the leaves. In another experiment the leaves were placed at the disposal of the sheep, and the ten animals ate 67.6 kilos, their health not being in any way affected. The example may be cited of a German farmer who fed his milch cows very extensively with beet leaves, and with surprising results, for the flow of milk increased and the quality was satisfactory, containing 4 per cent. of fatty substances. It is to be noted that during the early period of feeding there is always a diarrhœa, which lasts for about three weeks, and the animal fed has a very debilitated appearance; then there follows a reaction for the better and the fattening is very rapid. Beeves fed for two to three months on beet leaves and tops increased considerably in weight. Under no circumstances should leaves be fed to cattle or sheep during the period of gestation. Working oxen, after beet harvesting, prefer beet leaves and tops to almost any other kind of fodder. Farmers who have the slightest apprehension as to the feeding of beet leaves to cattle should give the product a trial in combination with chopped straw, etc., to which may also be added certain oil cakes. If the ration consists of $\frac{2}{3}$ leaves and $\frac{1}{3}$ tops, about 60 lbs. may be fed per 1000 lbs. live weight; if only 30 lbs. are fed, then it is desirable to add hay, straw and about 6 lbs. of oil cake.

As a ration one may give to cattle the combination proposed by Grouven: For heavy cattle 40 lbs. of soured leaves and the same quantity of soured cossettes, 3 lbs. of colza oil cake and 6 lbs. of hay.

Money value of beet leaves and tops.

When one discusses the money value of beet leaves and tops from a feeding standpoint their digestibility must be taken into account. While it is admitted that all the nutrients these contain are digestible, it is thought desirable to deduct 20 per cent. from their supposed money value.

Upon general principles it may be admitted that the tops are twice as nourishing as the leaves. All calculations made the tops and leaves worth in Germany about 8.25 cents per 100 lbs. or $1.80 per ton, about $8 to the acre.

In order to show the economical advantages of the utilization of beet leaves it is interesting to give as an example Germany, where 440,000 hectares, 1,100,000 acres, of beets are harvested, and where they do not rely upon more than two tons of dried leaves per hectare, which are worth 80 marks per ton, the value considered as a whole reaching seven millions of marks for their sugar campaign, which is a sum not to be ignored by any one.

Feeding seed stalks and seed.

The experiments made upon pigs at Göttingen, with the stalks of beet seed, showed that they were composed of only a very indefinite nutritious value. The experiments made at Halle-sur-Saale experimental station demonstrated that this residuum was possessed of only a moderate nourishing value and had a coefficiency of digestibility of only 64.02 per cent., viz., about equal to the straw of cereals in general and of rye in particular. Old beet seed, which for special reasons cannot be utilized, may be ground to a powder and advantageously used for fodder.

PART THIRD.

CHAPTER I.

Feeding Fresh and Siloed Sugar Beet Residuum.

Early appreciation of the value of sugar beet residuum cossettes.

FROM the very origin of the beet sugar industry it was suggested that residuum from the beet sugar factories should be used for cattle feeding, and if one consults the work of Achard it will be noticed there are a few lines respecting this subject, but curious to say, long years elapsed before the question was given the attention it deserved.

The fact of being able to keep the residuum cossettes in an excellent condition during several months of the year, at a period when fodders in general are expensive, was a most important advantage that all intelligent farmers appreciated.

Objection to its use.

Many objections were made to this residuum pulp (as it was then called), but the arguments used were certainly erroneous. Frick relates that in 1850, when efforts were made to arrange a fodder out of pressed pulp—the residuum of hydraulic pressing, which was then in vogue—the same objections were maintained everywhere; for example, it was claimed that certain lice were often found in the stomach of animals fed, and that they had no other origin than beet pulps. Later on similar difficulties were contended with when endeavoring to arrange for the utilization of exhausted diffusion cossettes. Some farmers refused to recognize that the residuum contained any nutrients whatever, for at that time it was agreed that all the nourishing constituents of the products had been removed with the water during pressing.

The heavy percentage of water contained in the residuum pulp, when diffusion was first introduced, was another argument against the general use of this valuable product. It was thought that the health of the animals would suffer.

At first the fact was apparently ignored that the general fattening effect upon animals of beet cossette residuum from sugar factories, unlike the mash from breweries, was not to bloat. Cattle raisers, however, were willing to give the product a fair trial, and from that time forward certain encouraging results were obtained.

It was noticed that pressed cossettes had excellent keeping qualities, and even when fed in considerable quantities produced little or no diarrhoea, and in this manner all previous adverse arguments were overcome.

Manner of using.

The manner or the condition in which this residuum from beets was fed to cows always depended upon the existing condition of the sugar industry; also upon the various phases and processes which the sugar manufactory underwent at different periods of its development. At the start of this industry it was impossible to consider or to urge the use of the residuum in any shape other than that in which it left the hydraulic presses. Then there came a struggle to convince farmers of the importance of combining a suitable fodder with the after-products of the maceration process, and at last there was no longer a question of this mode. This was soon replaced by another method known as diffusion, which, from that time to this, has held its own. Furthermore, it became necessary to take into consideration other very complex questions, such as the impossibility of utilizing the enormous quantities of this feeding stuff in a very limited time, which resulted in great changes in the methods of keeping the same.

At the present day no other question is discussed than that of diffusion cossettes. For the benefit of those who may not be thoroughly familiar with the question, a few preliminary remarks may be of interest.

In what diffusion consists.

In order to obtain the rapid and complete extraction of the sugar from the beets, the root is reduced to small slices, each having a section closely resembling the letter V. These slices are called cossettes. The cossettes upon leaving the slicers are received in receptacles known as diffusers, in which they are in contact with circulating water. Under these circumstances an exchange is created between substances dissolved in the liquid contained in the interior of the beet cells and those of the exterior liquid. These transformations take place through the membranes of the tissue, and there is a real phenomenon of diffusion, which in reality explains the use of the word. The substances dissolved in the liquid of the cells pass through the porous membrane with different velocities, which depend upon their condition of fluidity and the complexity of their molecules. The saline substances are most rapidly diffused through the tissues. Then there follow the sugar, amides, and, last of all, the albuminoids, and the cellulose and pectic substances. Fortunately these transformations are in direct ratio to the degree at which exhaustion takes place in the diffusion battery.

The main object of the manufacturer. The main object the sugar manufacturer has in view is to extract from these cossettes as much sugar as possible and to leave behind a maximum, so to speak, of albuminoids and other substances which are likely to offer difficulties in the subsequent operations of the various phases of sugar extraction. These transformations will end at a certain point and the exhausted cossettes will ultimately consist of a residuum product that will be very valuable for cattle feeding.

Composition of diffusion cossettes. As all the substances dissolved in the liquid of the cells and the order in which they diffuse are known, we are able to approximate, with a considerable degree of accuracy, the composition of the final exhausted cossettes. They are poor in sugar and relatively rich in albuminoids and pectic substances. The salts have also been eliminated to a considerable extent. This product as it leaves the diffusion batteries has about the following composition:

COMPOSITION OF COSSETTES AS THEY LEAVE THE DIFFUSION BATTERY.

SUBSTANCES.	Stammer's experiments.	Briem's experiments.
	Per cent.	Per cent.
Water	95.45	94.0
Cellulose	3.32	1.4
Albuminoids	0.36	0.5
Ash	0.30	0.4
Extractive substances	0.57	3.6
Fatty substances	——	0.1

It becomes very evident that one cannot consider these figures as being possessed of absolute value. They evidently vary with the original composition of the beets and their physiological condition, which has previously allowed diffusion to take place more or less rapidly, thereby permitting the dissolved substances contained in the cellular tissues to pass through the outer walls at a more or less rapid rate.

Sugar left in the residuum.

The composition furthermore depends upon the method of manufacture, the process of diffusion and the degree of exhaustion to which the beets have been submitted in the diffusion battery. Suffice it to say that there are many sugar factories which allow 0.8 per cent. of sugar to remain in the residuum, whilst at other factories the percentage is 0.15 per cent. Degner urges that there be left a few hundredths per cent. of sugar.

Excess of water.

What strikes one especially in these data is the enormous quantity of water that remains in the residuum, and every effort should be made to reduce this to a minimum in all cases. It stands to reason that such an excess would be deleterious to the general health of the animals to which it might be fed. The methods proposed to reduce this water percentage are very different and depend essentially upon the various factories where they have been introduced, so that we cannot at present enumerate them in detail. It is customary to resort to a mechanical method which reduces this water at least 50 per cent.

The desirability of eliminating the water of diffusion pulps is an open question. When it is to be consumed near the beet-sugar factory, the product may be thrown into silos upon leaving the battery; the water runs off by natural pressure of the mass. This plan would not be practicable, however, when pulps are to be carried to distant farms; hence, upon general principles, we may admit that a reasonable pressure is desirable.

Dripping and straining.

Some authorities urge that such a reduction is unnecessary; we, however, are in favor of resorting to considerable pressure. The ordinary method of straining the cossettes and allowing the water to drip off, so to speak, gives only fairly satisfactory results. Some allow the water to drain off upon inclined planes; the semi-strained mass is then laid on wagons, where the dripping continues. Under these circumstances 60 per cent. of the water of the cossettes is separated, which is a fraction more than that which can be removed by mechanical pressing. According to Wicke the residuum thus obtained contains 8.5 per cent. of dry substances. On the other hand, Bodenbender, who has also made some experiments in endeavoring to drain this water from the product, has obtained strained cossettes containing 85 per cent. water. In these same pulps the water is reduced to 50 per cent. after siloing, which would tend to confirm the argument of Schotter, who declared that this pressing was not necessary when the residuum was not to be kept for more than eight months. He claimed that after this time, pressed or not pressed, the residuum always had the same composition.

Cossette presses. The straining method has very little practical value for large factories, and it is now customary to submit the cossettes upon leaving the battery to considerable mechanical pressure. To accomplish this an almost unlimited number of cossette presses has been invented, but the results obtained with each of these are approximately the same.

When first introduced they gave a residuum containing 9 per cent. of dry substances. Little by little the improvements resulted in an increase in this percentage, owing to a greater quantity of water being expressed. As a result the dry matter remaining in the best known apparatus is 15 per cent., and it must be understood, too, that this is by no means the limit that such machines may attain.

Excessive pressure. There are, however, certain obstacles to be overcome, which in a measure prevent the progress that one might expect. Excessive pressure would reduce the cossettes to a paste, and this would be objectionable, as one looks for a certain dry pulverulent condition of the product ultimately desired, which consistency the cossettes generally possess after leaving the typical presses and in which form the product may be easily handled. Furthermore, this paste product would pass through the perforated iron filtering surfaces of the presses, and would, under such circumstances, obstruct their proper working. An excessive pressure would also decrease the percentage of nutritive elements, as some would be carried out with the sweet water escaping when the sides of the beet cells are broken open.

Losses during pressing.

According to Bartz, one loses about 0.28 per cent. of the proteid substances passing out in the sweet water of the cossette presses, when one obtains for the total weight of the beets worked 50 per cent. of pressed cossettes, which is about an average.

Maercker, however, declares that this loss is very much less. He has pressed the cossettes so that they are reduced to 18.41 per cent. of their original weight and, notwithstanding this excessive pressure, there does not remain in the sweet water running off more than 3.35 per cent. of the total dry substances.

On the other hand, Stammer declares that this loss is very much greater, even when submitted to less pressure, and that the weight of cossettes is reduced to 38 per cent. with a consequent loss of 5.5 per cent. of dry substances in the sweet water forced out from the residuum.

The essential reason for this diversity of data may be explained by the composition of the cossettes submitted to pressure. The more complete their exhaustion during diffusion the less will be the loss of dry substance during subsequent preparing.

It is interesting to note that in the experiments of Stammer, it has been demonstrated that the loss of saline substances in the sweet water is 32 per cent., while for albumen and extractible substances the loss is only about 12 per cent. of the total original quantity.

This same authority declares that the actual loss of nitrogenous substances during preparation was not more than 0.03 to 0.04 per cent. of the weight of the beets handled; furthermore, that before preparing, there was 7.4 per cent. albumen in 100 parts dry matter contained in the cossettes, and afterwards the percentage was reduced to 6.56 per cent.

Classen has also found that this loss is considerable. He has pointed out that even with a slight pressure the losses of nitrogenous substances reach 7 per cent., and the non-nitrogenous 9 per cent. On the other hand, by excessive pressure, the loss is 10 per cent. of nitrogenous, and 15.04 of the non-nitrogenous substances. He, therefore, justly finds that these are no longer insignificant quantities that may be overlooked. Happily, the average for the general work always results in certain compensations for these losses.

Frühling and Schultz have obtained the following results by pressing in a Bergreen apparatus: In the pressed cossettes there was 12 per cent. dry substance, and 0.66 per cent. in the sweet water, of which 0.23 per cent. was ash, and 0.16 per cent. proteid substances. Below is given the analysis of the residuum before and after preparing:

ANALYSIS OF BEET RESIDUUM BEFORE AND AFTER PREPARATION.

Substances.	Before preparing.	After preparing.
	Per cent.	Per cent.
Water	94.0	89.8
Ash	0.4	0.6
Raw protein	0.5	0.9
Fibre cellulose	1.4	2.4
Nitrogen free extract	3.6	6.1
Fatty substances	0.1	0.2
Digestible.		
Albuminoids and amides	0.3	0.6
Nitrogen free extract	3.0	5.1
Fibre	1.2	2.0
Fatty substances	0.1	0.2

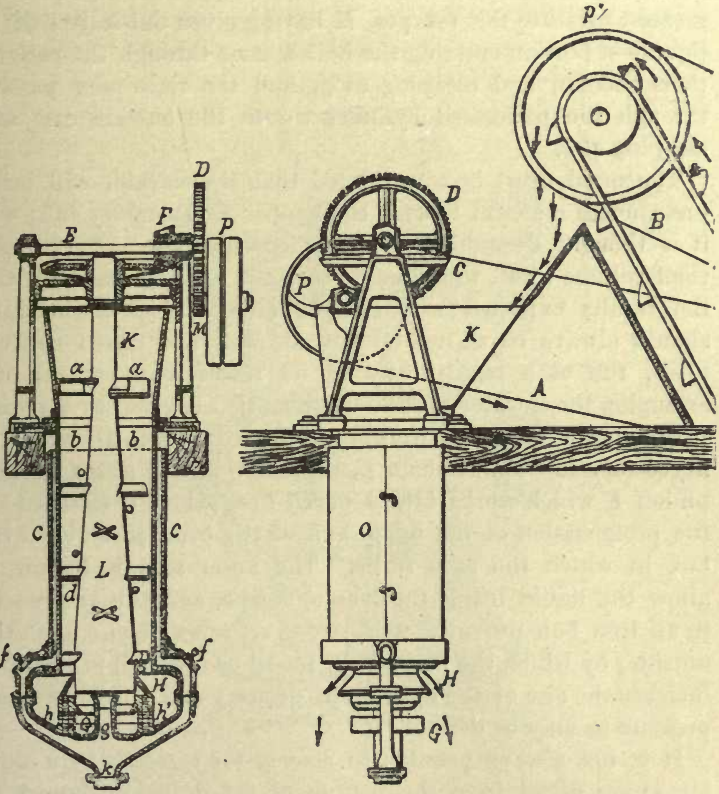
An examination of these data shows beyond cavil the advantage of pressing.

The presses now generally used are of the Klusemann or the Selwig and Lange types, the Klusemann press being the outcome of Schlickeysen's suggestion.

Klusemann press.

A side view and section of one of these presses is shown in Fig. 3; in many respects it is one of the best known. They may be seen in operation in most beet-sugar factories. As a general thing, they give entire satisfaction. If this machine does not extract the fluid as fully as the hydraulic press, it does, working continuously, deliver the pressed mass containing 12 to 14 per cent. of dry substance, almost equal in value for cattle-fodder to ordinary beets, and also valuable as a fertilizer. The idea of Klusemann's press evidently came from the clay-mixing machine, which has been used with so much success for mixing pressed clay with water. Here, as in the clay-mixer, the mass is worked by knives and screw-formed cutters, and is, at the same time, forced through a very contracted opening.

FIG. 3.



Side View and Section of Klusemann Press.

In the Klusemann press this is effected by a perforated cone *L*, which works in a perforated cylinder, and is furnished with iron or steel blades placed in screw form. These blades seize and force down the cossettes which are fed in at the top; and as the cone expands at the bottom, and the cylinder is of equal diameter throughout, it is evident that a strong pressure must be given to the cossettes as they approach the contracted opening between the cone and cylinder at the bottom.

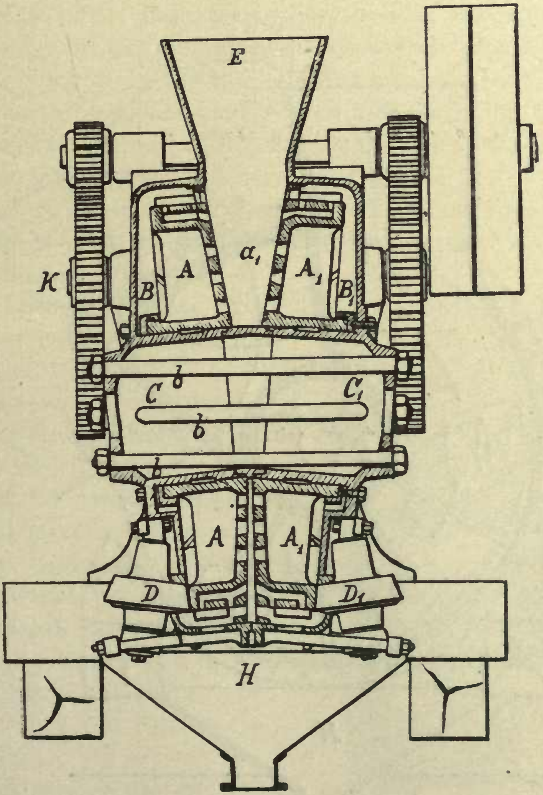
This press, as shown, is fed with cossettes, which, after leaving the elevator *B*, fall into the hopper *K*. The cone *L* with its flanges then carries the mass down, pressing it against the circumference *d* of the cylinder. As already stated, the pressure increases as the mass is forced downward, and at the point of greatest pressure this escapes, *H* having given out fully half its liquid—a portion entering the hollow cone through the perforations therein, and escaping at *g*, and the remainder passing through the perforated cylinder *c* into the outside case and escaping at *k*.

The speed must be so regulated that the elevator will bring just enough material to keep the hopper *K* constantly full; and it is thought desirable, when the cossettes are not in sufficient volume to fill the same, to stop the machine, as otherwise the results expected will not be obtained. The machine should always be started slowly at first, and when entirely filled, run at a regular rate of 50 revolutions per minute, arranging the elevator to suit. The motion is given by a pulley *P* carrying a pinion *M* working in the cog-wheel *D*, which is keyed on a horizontal shaft *E*, the latter having also a beveled pinion *F* which works into a beveled cog-wheel *C* fastened on the prolongation of the upper axis of the cone, just above the box in which the axis turns. The lower axis is hollow to allow the liquid inside the cone to escape, and this axis works in an iron box provided with strong set-screws *h* and *h'* on the outside, by which the box can be raised or lowered, to lessen or increase the size of the opening of delivery and the consequent pressure as may be desired.

It is not always possible to convey the cossettes by a moving apron direct from the bottom of the diffusion battery to the hopper *K*. But frequently it is emptied in any part of the building, and the refuse conveyed by an Archimedean screw into the presses. One advantage of this press is, that it requires no care and little or no attention; but what is to be regretted is that the pulp has not the fresh appearance it had prior to the pressing. Fifty tons of cossettes may be worked in twenty-four hours through one press of this description. This amount may be increased by increasing the diameter of the apparatus. The force required is said to be about one and one-half horse-power.

Modifications have been made by Bendel and Bergreen, also by Buttner and Meyer, but the general principle remains the same.

FIG. 4.



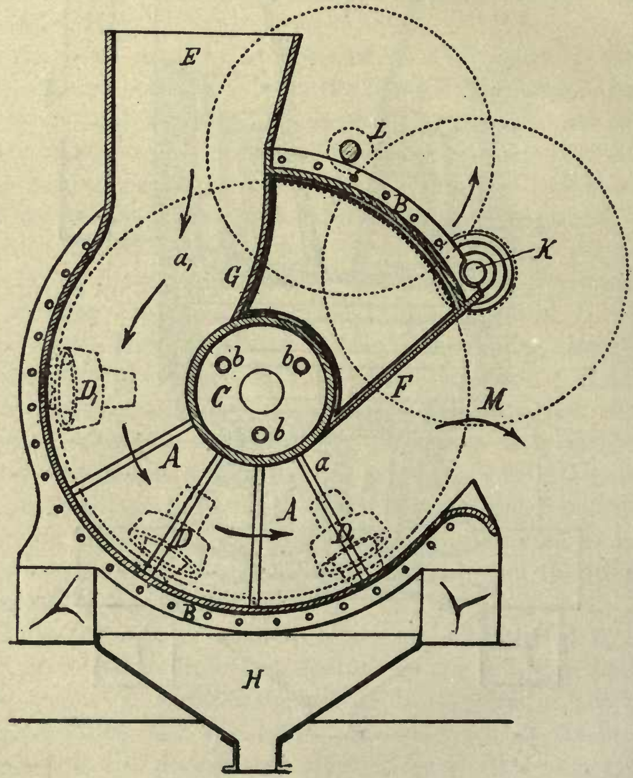
Vertical Section—Selwig and Lange Cone Pulp Press.

Selwig & Lange press.

The Selwig and Lange presses work upon an entirely different principle. This press, which is shown in Figs. 4 and 5 in two sections, presses the cossettes in the following manner:

The hopper *E* receives the cossettes, which fall at *a*, between cast-iron jaws, covered with perforated tin; these are placed obliquely to one another, and revolve upon the circumference of a large hollow cylinder made of two conical parts. The movement is very slow, and is the same for both disks. It depends upon the velocity of the driving pulley, upon the axis of which are two pinions that gear with large cog-wheels, these communicating the movement to the exterior circumference of the press. But as at *a*, the distance between the surfaces of the

Fig. 5.

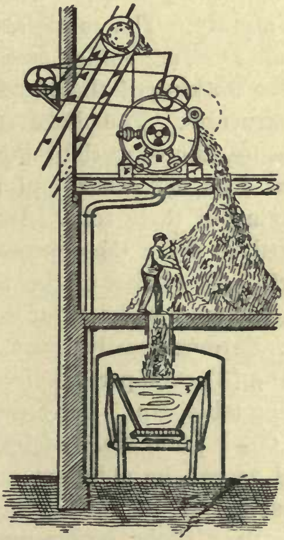


Transverse Section—Selwig and Lange Cone Pulp Press.

disks is the greatest, and at *a* the least, the cossettes reach a contracted wedge-shaped chamber whose walls continually move towards the smallest space, and are carried around by the friction and rotation of the disks. As the latter gradually approach the narrowest portion of the space *a*, the narrowing disks exert a most powerful pressure on the cossettes, while the liquid contained in the latter passes through the perforated surfaces of the pressing disks. The pressed cossettes, passing the narrowest portion *a*—after which the distance between the disk-surfaces again widens—are forced by the following mass against the fast scraper *F* out through the opening *M* in the jacket, and form a tolerably consistent mass. The pressed-out water flows through larger openings in the jacket, into a drain *H*.

The degree of pressure on the cossette, which is in proportion to the distances between the disk-surfaces $a_{,,}$, *a*, can be altered by altering the press disks *A*, $A_{,,}$, which can be moved on the axis C $C_{,}$ by set-screws provided for that purpose.

FIG. 6.



General Arrangement of Cone Press.

The cone cossette press can be placed either on the surface of the ground, or over chambers which can be used for other purposes, provided the liquid can be carried off properly, since the machine has no separated parts, and the pressed cossettes fall from it at the height of one metre, so that a transporter can be run under to be filled, and carry the cossettes to another place.

In most cases it would be best, especially if Klusemann's press is to be run with it, to arrange this press directly under the cossette elevator, in the story over the cossette storage room, as shown in the accompanying small cut. When there is sufficient height for the elevator above, two presses can be thus conveniently located.

In new buildings, or when altering buildings, it is recommended to place the press in the factory, and not in a separate building, which is usually colder, since experience proves that the cossettes can be pressed to much greater advantage in a warm than in a cold place. In such a case the pressed cossettes can be carried by a wheeled transporter, an endless screw, a link belt, or some other arrangement into the cossette store-room, and the building need not be more than two stories.

The press is driven by fast and loose pulleys on the shaft *L*, turning a pinion which works into the cog-wheel *K*. As soon as the hopper *E* begins to get empty, the press can be put to work; for, if it be not sufficiently filled, the pressing will not be so well done. It is important that all the shafts and the cog-wheels be kept well oiled and greased.

The construction of this press is said to be simple and very strong, having no parts which are easily broken, or which wear out rapidly. The materials used are the best; the iron press-rollers *D D*, are chilled castings.

The working of these presses is said to be as simple as their construction. The disks squeeze the cossettes with a direct pressure, almost at right angles. Slipping of the cossettes upon them does not occur, and therefore there is no tearing or destroying of their cells. In consequence of this the power required to drive these presses is much less—one-fifth or one-fourth only of that of the Klusemann press of equal capacity.

Advantages claimed for the conical cossette press are:

1. Extraordinarily great delivery, with excellent pressing. Of the (3) cone presses of varying dimensions, given in the following table, No. 1 has a capacity of 250,000 k. daily; No. 2 of 190,000 k., and No. 3 of 100,000 k.; and the work is equally as good as can be obtained on an average from the Klusemann press.

2. Very slight power required—only one-third to one-half horse-power per 100,000 k. daily of beets worked, being only twenty to twenty-five per cent. of the power needed for the Klusemann press. In consequence, 100 tons of beet cossettes can

be pressed with this machine daily. The economy of coal is apparent.

3. Great simplicity of construction, and entire safety in running.
4. Very little loss of time by stoppage while at work.
5. Better keeping quality of the pressed cossettes, which also are not cut up too fine. These pressed cossettes are said to keep much better in consequence thereof in the silos, as is proved by experience.
6. Lower price of these machines and cheaper setting, compared with other presses of equal capacity.

DAILY DELIVERY OF 3 CONE COSSETTE PRESSES OF VARYING DIMENSIONS.

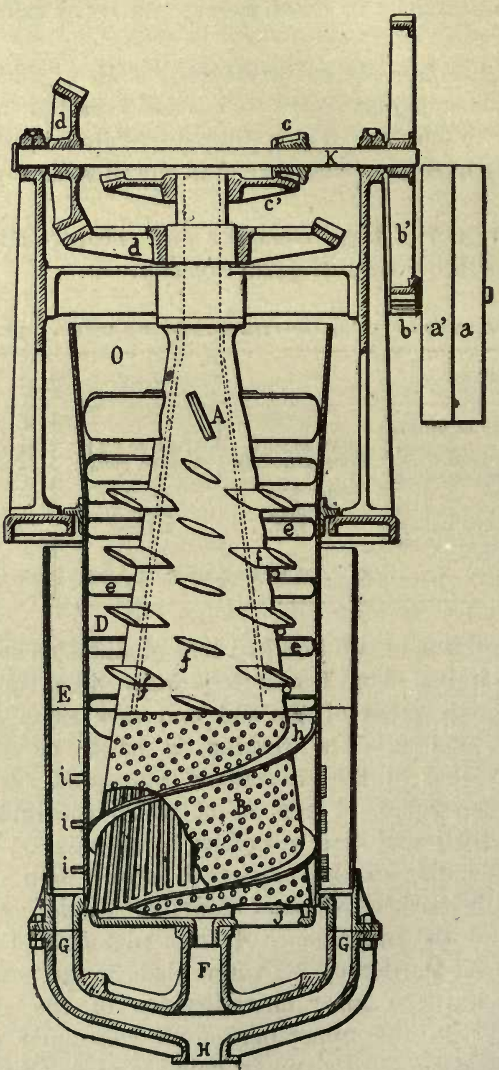
Dimensions, etc.	*No. 1.*	*No. 2.*	*No. 3.*
Delivery per day of worked beets	225 t. to 250 t.	150 t to 165 t.	100 t. to 110 t.
Diameter of press disks	1.800 m. (70″.81)	1.450 m. (57″.04)	1.200 m. (40″.15)
Number of revolutions of same *per minute*	0.60–0.70	0.85–1.0	1.1–1.3
Diameter of driving pulleys.	785 mm.	940 mm.	785 mm.
Dreadth of driving pulleys.	155 mm.	155 mm.	130 mm.
Number of revolutions pulleys, per minute	67–78	33–39	41–49
Weight of the press	7000 k. (15,400 lbs.)	5200 k. (11,440 lbs.)	3600 k. (7,920 lbs.)

For the pressing of two hundred tons of diffusion cossettes in twenty-four hours, about two horse-power will be required.

Bergreen press.

The Bergreen press of the old and new types is shown in Figs. 7 and 8. Its working is based on the same principle as that of the Klusemann apparatus. It consists mainly of two cones, *A* and *B*, of which the interior one, *B*, is perforated and has a hollow lower axis, *F*, for support and the exit of the expressed juice. Both cones are provided with iron screw-formed blades of which those on the upper half of the outer cone, *A*, form segments of a screw, while the lower portion of the screw blade is continuous, and almost touches the inner circumference of the perforated cylinder, *D*. In the upper portion of this outer cone the separate blades, *e e* and *f f*, run in spiral form, but in opposite directions. The blades, *e e*, form a low, sloping screw, while those of *f f* are steep. The former being also broader, spread and mix the mass, while the steep winding of the spiral, *f f*, forces the mass downwards with pressure. In the outer

FIG. 7.


d
c
K
c'
d
b'
b
a'
a
O
A
e
e
D
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f
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E
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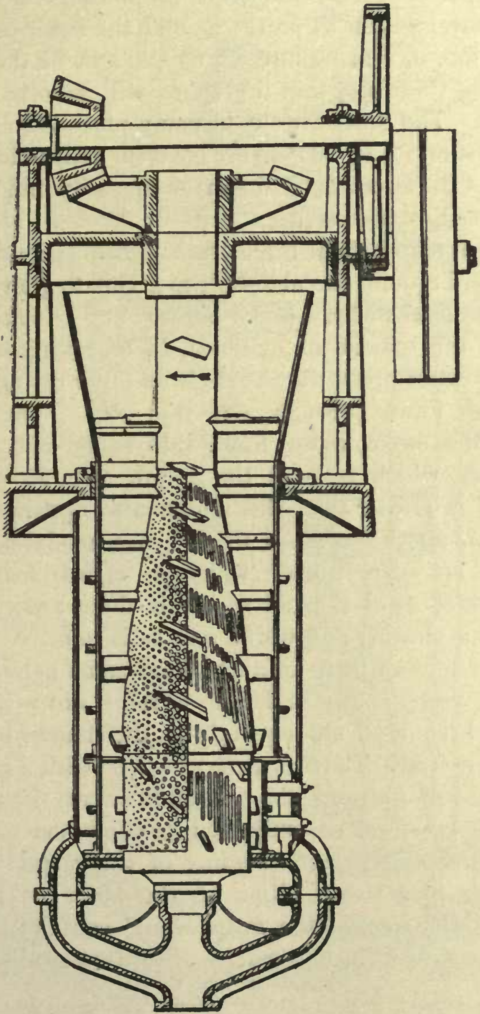
B
i
i
i
J
G
G
F
H

Bergreen Cossette Press (Old Type).

cylinder the blades, *e* and *f*, move in a spiral from left to right, but the similar blades on the inner cone move spirally from right to left.

FIG. 8.



Bergreen Cossette Press (***New Type***).

As the two cones move in opposite directions this arrangement forces the cossettes from the upper broken spiral into the lower continuous spiral. The motion is given by the pulley, *a′*, on whose axis a pinion, *b*, works into a large cog-wheel, *b′*. On the horizontal axis, *K*, two pinions of different sizes are placed opposite to each other, the smaller of which, *c*, gearing into the bevel wheel, *c′*, on the axis of the inner cone, and the larger pinion, *d*, gearing into *d′*, on the axis of the outer cone. It is plain, therefore, that the cones will revolve in opposite directions. The cones are slit in many places, as shown on the broken portion of *B*. These are covered with finely perforated tin, so that the sweet water may run off easily and at the same time be freed from cossettes.

There is a man-hole at the bottom of *B* to afford access to the interior, and around the man-hole is a rim to prevent overflow of the expressed water. *C* is a hopper, and *i i i* are three iron bands on the outside of cylinder, *D*, to strengthen it at the point of greatest pressure. There is an outer casing, *E*, whence the liquid flows through *GG* into *H*. From the inner cylinder the sweet water flows into some exit through the hollow axis, which rests in the hollow step, *F*. The cost of this press is greater than the Klusemann apparatus. During recent years another press of the Bergreen model has come into existence, an engraving of which is shown herewith. The outer portion, *A*, of the old model is done away with. This apparatus is cheaper and works very satisfactorily.

Lallouette press.

Another mode which for a time had some popularity, is the Lallouette press, shown in Fig. 9, which is not without interest as it has been used subsequently to the standard Klusemann and other presses. The filling may be done with a pulp-pump,* and 15 tons of pulp may be pressed in twenty-four hours. In France this press was not only used for the refuse beet pulp, but also for first and second pressing of the rasped beets. Mr. Lallouette's idea was to diminish the water in excess in the diffusion pulp, so that the latter would contain no more of it than the pressed diffusion cossettes. His experiments consisted in placing a small quantity of the pulp in the press, then a

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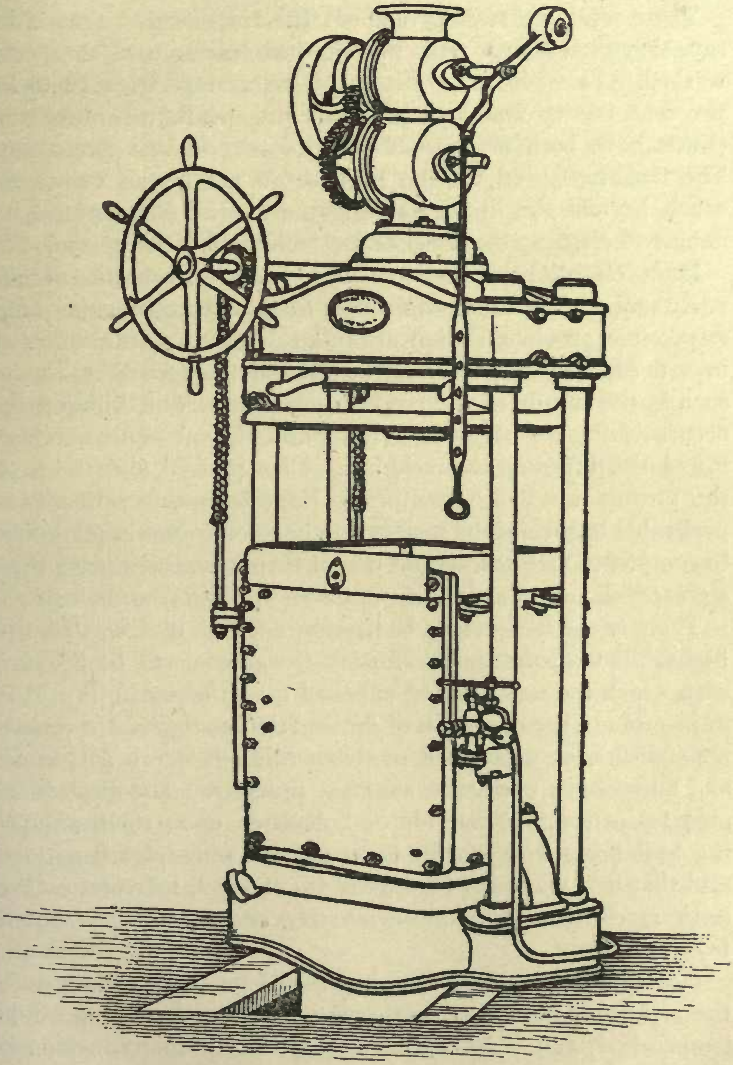
* The pulp-pump is of curious construction. The valves must be necessarily made large, not only to permit the passage of the liquid, but also of substances in suspension.

FIG. 9.



Lallouette Press.

layer of linen cloths, then a layer of pulp, etc., alternately, until full—the capacity being 250 k. [550 lbs.]. The whole, after being pressed from seven to ten minutes, was reduced to 170 k. [375 lbs.], about 40 per cent. of water being eliminated.

These several presses give about the same results: that is to say, they give 50 per cent. in weight of residuum of the beets worked. This product contains on an average from 12 to 14 per cent. of dry matter. As was before mentioned, numerous efforts have been made to increase this dry matter percentage. The machines used for the purpose do not permit one to go much beyond the limits named, as otherwise there would be danger of clogging the mesh of the perforated filtering iron.

Care needed during pressing. It is essential to see that these presses run with regularity and to keep them constantly filled with cossettes as long as possible. As long as they are full, the cossettes are submitted to a normal pressure against the sides of the apparatus, but as soon as the supply of the residuum decreases, which frequently occurs during an irregular working and the subsequent emptying of the diffusors, the residuum is not pressed and it leaves the presses in a moist condition. Experience shows that it is preferable to supply the cossettes to one press after another and to commence with the central one of the series, there being thus a greater chance of at least two presses working continuously.

Heat facilitates pressing. There is one fact not to be overlooked, and that is, that the higher the temperature of diffusion the greater will be the ease with which the water can be expelled from the residuum. It is impossible in the operation of diffusion to go beyond a certain temperature, at which the final residuum becomes gelatinous and bursts open under the slightest pressure. The most desirable temperature is variable and depends upon the tissues of the beet being worked, but upon general principles it may be said that it is very near 80 degrees C., at which temperature the cells reach their maximum porosity and allow their liquid to escape freely.

Modes for facilitating pressing. For several years past there has been a tendency to introduce the residuum into the cossette presses at the highest possible temperature, and it is for this reason that, in many instances, diffusion is conducted with hot water. Certain manufacturers have gone so far as to mix hot water with the exhausted cossettes in order to reheat them, while in other cases it has been customary to reheat this residuum by bringing it in contact with live steam.

Maercker attempted to obtain the same result, not by heat but by chemical reactions. After a long series of laboratory investigations he concluded that when the cossettes were mixed with lime or alkaline salts, the cellular tissues of the product became very much more porous. The most efficacious method is the least expensive. It consists in submitting the cossettes to the action of 0.5 per cent. of lime, using it in the form of milk of lime. The receptacle in which this mixing is done has a suitably-arranged agitator which produces a perfectly homogeneous mass. This operation lasts from 20 to 30 minutes, and the product thus obtained gives up a large percentage of water under the slightest pressure. Some investigators who have introduced this milk of lime treatment claim that the percentage of dry substances in the final pressed product reaches nearly 30 per cent. (?), that the limed cossettes were possessed of an agreeable flavor, etc.

Siekel also recommends this mode of working, but under no circumstances should the residuum be allowed to be in contact with the lime for more than 30 minutes, as otherwise the physical condition of the product would be altered, and it would then, in a measure, be worthless for the purposes intended. It would be transformed in the presses into a compact mass, which it would be impossible to compress without a breaking of the press, and under such circumstances it would become necessary to cut it into pieces in order to remove it.

Muller proposes the washing of the cossettes in lime water before pressing. Under this treatment the residuum increases in value as a fodder, and the lime will constitute later on an obstacle to the excessive fermentation in silos, which is always to be dreaded.

The theory of the Manoury method is based upon the simultaneous action of heat and a suitable chemical, which coagulates the albuminoids in the tissues of the beet. Its application to diffusion consists in adding lime to fresh beet cossettes during the diffusion at 70° C., allowing the contact to last for at least 20 minutes. The cossettes subsequently give excellent results by pressure, and their weight may be reduced to 15 per cent. of the weight of the beet.

The mixing of the lime with the cossettes may be done in many ways. The weak juices running from the diffusion battery are used again instead of water for the general working of the battery. The advantages of such practice are as follows: 1st. Considerable diminution in the quantity of water required for diffusion. 2d. The saving of 0.3 to 0.4 per cent. sugar, which is frequently lost in the refuse water and cossettes. It is said that juices extracted by this method are at least as sweet as those from the first carbonatation, consequently the latter operation may be effected with 1 per cent. of lime, giving a purity equal to that obtained with 3 per cent. by the customary process. It is estimated that by an additional expense of $1,600 there would result an advantage of $1.40 per ton of beets, and for an ordinary campaign a saving of over $12,000. These figures, if correct, are of sufficient importance to warrant their careful examination by every beet-sugar manufacturer.

Bosse urges that the several modes mentioned in the foregoing be combined. He submits the residuum to hot water and alkali during pressing, and re-heats the cossettes on leaving the diffusors in a large receptacle containing ammoniacal water, which is collected during the evaporation of the juice in the triple effect.

Scheermesser uses in the last diffusor of a diffusion battery, water that is saturated with anhydrous sulphurous acid. Under these circumstances the resulting residuum is easily pressed, and the albuminoids are coagulated by this acid, under which conditions they will be retained in the cossettes that are pressed, and will not pass off in the sweet waters. When the product is dried and left in the air for a certain time the anhydrous sulphuric acid seems to evaporate, but it remains to be proved whether the product could be advantageously fed to cattle.

Pulp or cossette contracts. Most farmers in continental Europe, when contracting to grow beets for the sugar factories, stipulate in advance that they must have in return at least 50 per cent. in weight of the beets furnished. Under these circumstances it is to the manufacturer's interest to have the largest possible quantity of residuum cossettes. Unfortunately, very dishonest methods are frequently employed to obtain the same, in which case the manufacturer has no special advantage in submitting the cossettes to an excessive pressure.

Furthermore, it would be to the interest of the tiller to stipulate in his contract that the residuum shall contain a certain quantity of dry matter. If this is less than 8 per cent. the product should be refused. As affairs now stand the farmer frequently receives water instead of the valuable constituent just mentioned, and can derive no benefit from it. On the other hand, when the water has not been removed the mass of cossettes has considerable volume and the cost of its transportation is considerably higher than it should be. Furthermore, the nutrients contained in the product are frequently so diluted that they have a pernicious effect upon the health of the animals being fed.

Value of sugar beet cossettes.

The market value of residuum cossettes from sugar factories depends upon many conditions; their composition, the manner in which they are obtained, the abundance of other crops and distance from factory to farm. In most European countries contracts are made between farmer and manufacturer for beets at $4.00 per ton, the farmer reserving the privilege of purchasing the residuum pulp at $1.00 to $2.00 per ton, in quantities corresponding to ⅕ of the weight of beets furnished. When pulps are delivered at farms allowance is made for such transportation. Considerable change occurs in the composition of the product during transit. The percentage of water increases cost for example, if 80 carts are required to carry a given weight of pulp containing 80 per cent. water, 85 carts would be necessary for transportation of the same pulp if the water percentage had been 85 per cent.

By means of oxen the cost of transportation of pulp to a farm at average distance from the factory, is 15 cents per ton. This price permits keeping oxen, or other animals used, in good condition, and in a few years pays their value. Difficulties constantly arise between manufacturer and farmer; either the latter wants more than his contract calls for, or he maintains that the refuse is inferior in quality to the product formerly used. As the percentage of cossettes obtained varies with the saccharine quality of the beets worked, it is well for the manufacturer not to make any rash promises as to the amount he can furnish and the quality of the product. Hence 20 per cent. is considered a reasonable limit. From 100 lbs. of beets there are obtained on an average 42 lbs. of cossettes; the difference should be consumed by animals at the factory.

Diffusion must be conducted under most scientific principles, otherwise the feeding-value of the pulp suffers. If the temperature is too high there follows a coagulation of many of the nutritive elements. To protect the farmers' interest and to make sure of harmony among all interested, an understanding should exist as to limits of temperature at which the battery is to be worked. If farmers sell siloed pulp to their neighbors, they should ask double the purchase price at the factory, to which should also be added the expense of transportation and siloing. The bulk is reduced one-half, but the value has remained unchanged.

These pressed cossettes are in some cases fed to live stock as fast as received or they are kept in specially built silos. Farmers collect the product at the factory in wagons or carts, or transport it by water in boats constructed for this purpose.

Conveyance of cossettes to farm.

Respecting this question of transportation, there is no special remark to be made, except that wagons, carts or boats which have previously served the purpose of carrying beets to the factory and have thereby become dirty on account of adhering earth, should in all cases undergo a special cleaning before being filled with the residuum cossettes. This cleaning also serves the purpose of diminishing the possible contamination of certain bacteria that frequently accompany earth of all kinds. These would necessarily bring about complex fermentation during the siloing.

Importance of keeping the residuum clean.

It is well to note that with forage in general it is always desirable not to allow gravel and sand, or other hard substances, to penetrate the mass, as these would produce a disagreeable sensation during the process of rumination.

When it is desirable to feed the cossettes just after they leave the presses, it is important that it be done as soon as possible, as they rapidly undergo transformation, due to bacteria absorbed or taken from the air, which soon find in the cossettes an excellent medium for their development. The micro-organisms also existing will necessarily produce an objectionable fermentation, which has no relation whatever to the healthy fermentation occurring during the siloing.

Changes when exposed to the air.

Cossettes exposed to the air soon give evidence of putrefaction, which render them worthless for feeding purposes. Under no circumstances is it recommended that cattle be fed with cossettes alone. However, certain practical experiments have shown that no special evil effects arise from this practice; but their composition, as shown above, demonstrates that this residuum, like all fodders, is not complete within itself.

Not to be fed alone to live stock.

Exhausted cossettes are very poor in fatty and saline substances. Their dry constituents consist mainly in non-nitrogenous substances of only an average nutritive value, their carbohydrates are mainly cellulose and penta-glucoses; but the reasonable percentage of albuminoids which the residuum contains, renders this product a fresh and valuable fodder, notwithstanding its heavy percentage of water, which necessarily dilutes the nutritive substances. The deficiency of saline substances is partly overcome by the addition to the ration of a small quantity of salt mixed with the cossettes, or, as is frequently done, a large block of salt may be placed at the animals' disposal, which they can lick to their hearts' content, their appetite being thus stimulated.

Feeding value of cossettes.

It is, upon general principles, desirable to add a certain amount of lime or phosphoric acid in the form of phosphate, which is necessary for the building up of the bony tissues. As to lime, it is sufficient to mix with the forage any calcareous substance, such as carbonatation scum. This is essential, as many who have had experience in the special subject of cattle-feeding and dairying in general declare that when cheese is the object in view, lime should not be used too sparingly, as otherwise the cheese would not be possessed of the essentials for coagulation. On the other hand, the phenomenon of faulty

Importance of adding lime.

coagulation is attributed to the contamination of the milk with the micro-organisms with which the cossettes become saturated when brought into contact with the air of the stable.

Phosphoric acid to be added.

Phosphoric acid may be supplied by mixing with the residuum pressed cossettes any forage containing this acid in a reasonable proportion. For this purpose one may use oil cake residuum of various origins. These are very valuable from another standpoint; they give the requisite quantity of fatty substances, which are entirely absent in diffusion and pressed cossettes. When these fatty constituents are absent in the forage fed to milk cows there follow certain difficulties in the production of butter.

Beet cossettes in cattle feeding.

The growth of our population and the increased value of lands, render the problem of cattle feeding much more complicated than formerly. Stall feeding is now more general than it used to be, but the custom in the United States is practiced only to a limited extent, as compared with Europe. The idea in view, however, in both cases remains the same, *i. e.*, to purchase cattle at the lowest price and sell with the greatest profit. That the selling price per pound increases with an increase in total weight of the animal is a well-known fact.

The fattening should cease when the conditions do not appear favorable for its continuance; that is, when interest of money and cost of fodder used are more than the money value of the daily gain in weight. The question of beet pulps for milch cows is of far greater importance than the average reader can at first realize; for, if the cost of production of a quart of milk can be made less than at present, there would necessarily follow a decrease in the selling price of that necessity of life, which would benefit the laboring class in general.

The fattening of sheep with beet cossettes has of late been conducted on a very extended scale in the United States, not only in California but also in Nebraska, etc., and it may certainly be made profitable in the Eastern States. Wool in abundance on American soil means cheaper clothing. Without attempting any other economic argument, suffice it to say, that beet-cossette residuum utilization is destined to take a most important part in the general prosperity of our country.

How to feed beet pulps.

No general rule can be given as to the best methods for feeding, as they depend upon the special circumstance of the locality. Siloed pulp, upon general principles, being better than the fresh, the farmer has every reason to give the silo his best possible attention. The ration should vary with the special animal to be fed; and samples of rations should not be considered as standard, but taken simply as guiding points in the experiment. With fresh pulps suitable quantities of oil cake should always be used, taking the precaution to mix them with a certain amount of chopped straw and fermenting the same in special vats.

Under these circumstances it is found desirable, to accelerate the fermentation by the addition of a small quantity of tepid water. It is well to have two vats, one fermenting while feeding from the other. To avoid hot water in excess, a slow heating of the mass is highly recommended by some; the effect of this system appears to be most satisfactory.

Dangers of feeding beet pulps.

Under certain circumstances live stock may decline the cossettes; then a mild system of starvation may be adopted. This method, however, from the writer's point of view, can never be made profitable, as the loss of weight could not be compensated by the economy in the cost of fodder used. The addition of condiments is one of the best methods; a little salt water frequently answers the purpose, and diluted molasses is most excellent. It may be desirable to mix with the pulp a very tempting fodder, and to diminish this gradually.

In the whole question of feeding beet pulps to cattle there are important facts not to be overlooked. When the pulp is fed fresh the main difficulty is overfeeding, or not properly preparing the ration to meet the requirements of the special case under consideration. Siloed pulps undergo organic changes during their keeping; first, they may become mouldy, second, saturated with excess of alcoholic vapors, and third, attacked by a certain disease known as pulp malady. The portions of siloed pulp that become mouldy are generally at the top, being more in contact with the air. Distillery pulp owing to its acidity keeps longer, consequently many conclude that a slight acidity is rather desirable. It is a great mistake to allow any mouldy pulp to be used, as death may ensue. No one has yet discovered the form of bacteria responsible for the trouble.

The saturation of pulps with alcoholic vapors is rather an advantage, as the cattle eat it with considerable avidity. The excess of alcohol in beet pulps is never as great with diffusion cossettes as with the hydraulic-press residuum, for the simple reason that the latter contains more sugar that could generate alcohol. During the period when presses were used as a means of extracting the juice from pulp during the regular process of manufacture, one would constantly hear of actual intoxication, the animals falling to the ground and remaining in an almost comatose state for a considerable time. After the effects had passed off they would rise and eat as if nothing had occurred. These alcoholic pulps would, after a time, cause cerebral complications. Before that period is reached the flesh has depreciated in value; this is, however, a difficulty at present almost unknown.

Beet pulp disease. A few years since it was noticed that in certain parts of France cows fed on well combined rations were suffering from certain organic complications. A young bull being fattened became suddenly ill. No cause could be attributed for the same. After death the animal was examined and found to have suffered from serious stomach and intestinal complications. Fortunately such instances are of rare occurrence, but it was discovered that the pulp used was from a very old silo.

The toxic elements existing, that will necessarily cause physical complications if taken into the system, are the outcome of the early stages of decay of the product fed. The objectionable microbes are found mainly in the water running off. At first the animals suffering from the disease are very restless; severe colics soon manifest themselves, and considerable suffering and pain always accompany these troubles. The most objectionable pulps are those that have been stored for a period of months. Practical experiments show that if the kept residuum is heated to 212° F., all the microbes they contain are destroyed. This, in fact, applies to most bacteria. This mode cannot be practically applied. Sodic chlorid or common salt offers one of the very best means of destroying objectionable microbes. This should be combined with pulps in the proportion of 0.25 to 0.30 per cent. It is important not to use it in excess. Every few days there should be placed at the animal's disposal a salt solution, permitting the animal to use its own discretion as to quantity taken.

Decomposed, or mildewed cossettes, should never be used for cattle feeding, as the general health of the animals fed would suffer. There would follow colics, swelling of the intestine, cramp, paralysis, etc., due to ptomaines and ferments, from which there is always to be feared a continued action upon the nervous system.

Arlaing attributes to sour cossettes certain diseases of the rennet. Stift declares that lactic acid, when present in excess, always means certain complications of the bony tissues. According to Gerland, notwithstanding all the water that the cossettes may contain, soured cossette feeding means diarrhœa only, provided there has been a sudden lowering of temperature of the intestinal tubes. On the other hand, these sour cossettes increase the secretion of the kidneys.

There certainly are many advantages in using soured cossettes rather than the fresh residuum, as they contain less water. An excessive consumption of cossettes may result in an excessive flow of blood to the brain or spine. Under these circumstances there follow intestinal troubles in the animals, resulting in death, owing to diarrhœa.

Conclusions as to dangers of cossette feeding.

All of these alleged dangers from feeding cossettes do not in any way reduce their actual value and excellent feeding qualities taken as a whole and considered as forage, provided, however, they be not fed to excess. It is desirable that the cossettes be not allowed to undergo any organic transformation during their keeping, the natural fermentation being the limit. Microbes that may be accidentally introduced will bring about complications, and it has been noticed that soured cossettes are particularly favorable for this bacteriological development. Many essays have been written which endeavor to demonstrate that it is to this source that we must look for nearly all the diseases that cossette-fed cattle have had to fight against. The technical discoveries in this matter have been such that efforts have been made to prohibit, in the working of the diffusion batteries, the use of certain waters which are supposed to contain microbes. It frequently happens in the manufacture of beet sugar that there is a scarcity of water, and under these conditions it becomes imperative to use the water that the manufacturer has at his disposal over and over again. However, compressed air comes to the rescue when water is scarce, and many advantages have been derived from its use.

While it has not been conclusively demonstrated that water contains germs which prove themselves to be decidedly objectionable, it has been shown beyond cavil that the cossettes appear to combine certain elements favoring putrefaction upon coming in contact with the unknown microbes during siloing, thus considerably increasing the losses occurring during this keeping.

The pulp malady is a comparatively new fad among scientists who declare that the trouble commences in the intestinal canal; diarrhœa is the second stage. While it is admitted that special microbes have been found in rotten pulps, it is interesting to note that it is not from the microbe the difficulty arises, but through internal complications. The toxic substances formed may be numerous, some of which are precipitated in alcohol while others are soluble therein. Their action in these cases is very different, and recent investigations appear to show that it is those elements soluble in alcohol which are the most to be dreaded, as they cause convulsions and frequently death. None of these difficulties will ever occur if the pulps are boiled or dried.

These facts have been mentioned as offering a certain interest for those who contemplate cattle fattening on an extended scale. It is also important to note that among many thousands of beeves fattened with beet pulp for the European market for a period of years, there has not been a single case where the farmers complained of any evil effects arising from an extended use of the residuum. When the difficulty does occur, the farmer himself is responsible, as when beet pulps are fed *alone* there may be some danger of osteomalacia (softening of the bones). Such practice of feeding can certainly have no advantage other than economy, which does not prove profitable in the end. The disease in question appears to be more prevalent among cows than oxen; the latter appear to be better able to resist any absorption from their bony frame. Let the ration contain enough salts (phosphate of lime, soda. potassa, etc.);* let the by-fodders have the saline elements needed, and the pulp malady will possess no more than a passing interest.

Feeding with the view to production of milk and butter.

There is a great difference of opinion as regards the value of beet pulp on dairy farms. Some say, that under all circumstances the milk from cows fed upon the product has an unpleasant taste and is worthless for the city market; others, on the contrary, argue that the milk is sweeter than can be obtained by the use of any other fodder; that the bad taste of milk is due to the use of inferior siloed pulp, which has undergone some alteration during keeping. The abundance of milk that follows pulp feeding no one doubts—the quantity is greater, but the quality diminished. Under all circumstances, it is certain that the results obtained depend as much upon the care taken as upon the fodder used. It would be impossible to give a full synopsis in the present writing of the numerous trustworthy and scientific experiments that have been made bearing on this question. However, a synopsis of a few of them are given:

1st. The daily ration during first week for a cow weighing 700 lbs. contained 38 lbs. rutabaga; the yield of milk was 5 quarts per diem; the second week 60 lbs. diffusion pulp, yield of milk 5.7 quarts; third week 121 lbs. pulp, yield of milk 6¼ quarts. The yield of milk consequently increased 30 per cent. The beet ration had little or no influence on the *casein*, which fact seems to be a general conclusion of all observers. The yield of butter increased 12 per cent.

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* Just whether common salt, if mixed with pulp attacked by the malady, overcomes all complications to be dreaded, remains to be yet thoroughly demonstrated. Some French experiments appear to prove that salt does not overcome the difficulty. The main thing to be avoided is the use of cossettes that have for a period of months been in contact with the stagnant water of a silo. In this respect cemented silos for beet pulp are objectionable unless thoroughly drained and those simply made in the ground are far preferable. An interesting fact not to be overlooked is that the lower strata of a silo may frequently be worthless for cattle feeding, while a few inches from the cossette upper surface may be in an excellent condition for sheep, cattle, etc.

When the feeding of diffusion or distillery cossettes to ordinary cattle has become a regular business, it is desirable to isolate the animals being fattened from other stock so as to avoid the spread of disease, when it occurs, to more valuable domestic animals.

2d. Among the most important experiments in this special direction are those of Andouard and Vezaunay, who fed pulp in constantly increasing quantities up to 138 lbs. per diem. Their conclusion was that the influence of pulp increases the yield of milk 34 per cent.; butter increased 6.74 per cent. After three months the weight of fodder might have been augmented 40 lbs. The objectionable flavor of milk was no greater than with the use of other fermented fodders. Beet pulps are very profitable in the production of butter and meat. It appears, however, that the milk obtained has a special tendency to acid fermentation.*

Continued feeding with cossettes.

Klein has noticed that after a long feeding with cossettes the resulting milk contains 2.22 per cent. less fatty substances than it did during the early stages of feeding. Upon general principles one may admit that this decrease is observable in cossette feeding in general. To counterbalance this argument it is well not to forget that the volume of milk secreted increases very considerably under the influence of beet residuum fodders, and under these conditions the total fatty substances secreted are in reality greater than with most fodders.

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* The American farmers having given the question of diffusion cossettes a fair trial, are pleased with the results. Besides the cases cited elsewhere, we may mention another where 100 head of cattle were fed upon beet pulps combined with other fodders. Small cattle were purchased in the autumn at 1½c. per pound, and were sold five months later at 3c. per pound. Beeves purchased at 2½c. live weight might subsequently be sold at 4c., their average increase being 230 lbs. It is recommended to purchase beeves weighing 1,200 lbs. at $30.00 each; the cost of feeding, including labor, will be about $23.00 each, total cost $53.00; such were sold at $71.50, the profit $18.50 per head. Under these circumstances it follows that if beet pulp utilization is not general it is due to the ignorance of those discussing the question. It is true the residuum when fresh is too bulky, but this objection cannot be urged when it has been properly siloed; furthermore, an extended feeding with fresh pulp would be a mistake. It appears to be generally forgotten that beet residuum from the diffusion battery is more nourishing than was the original beet.

Excessive feeding.

All investigators have not come to the same conclusion as regards excessive cossette feeding. According to Briem when this cossette feeding is pushed to an excess the resulting butter will have a very tallow-like appearance and bad taste, which objectionable features are most difficult to get rid of, even when the animals receive the requisite supply of palm-oil cakes, rice flour, corn residuum, etc. Furthermore, certain authorities declare that it is a mistake to give cossettes to cows that are to supply milk to be fed to babies, or to animals undergoing their period of gestation, or even when the calf is still sucking. But all these views are exaggerated, as pressed cossettes constitute a nutrient as healthy as any known forage for cattle that are being fattened or for those that are being raised.

Schulze points out that if 12 per cent. dry matter is sufficient for a forage being fed to milch cows, the conditions are the same for cattle fed with the idea of obtaining their manure or for breeding purposes.

Water in beet pulps.

European farmers, during a period of thirty years, have become thoroughly accustomed to using beet residuum from beet-sugar factories and distilleries. The product from the factory came from hydraulic presses and contained very much less water than the cossettes from diffusion batteries. Numerous discussions followed, showing that there was every advantage in using diffusion cossettes, notwithstanding they contained more water. This excess offered no difficulty when mixing with chopped straw or some other material that would absorb the moisture. Experiments show that an ox weighing 1,000 lbs. should not absorb more than 60 to 80 lbs. water per diem; if this limit is passed the weight of the animal being fed decreases. This is explained by the fact that the gastric juices of the stomach are then so diluted that assimilation of the fodder is not satisfactory; besides which, as Maercker justly argues, to evaporate this water a certain amount of the animal's caloric must be drawn upon.

The degrees of caloric necessary may be easily calculated, and reduced to the basis of starch—it being admitted that for every pound of starch-combustion in the body there is required a given number of degrees of heat. When water is in excess it will exert a reflex action upon the albuminoids of the body. An exceptional quantity of water taken into the body has a debilitating action owing to the dilution of blood that it brings about.

From this same standpoint it is a mistake to feed frozen cossettes. The freezing occurs during the transportation of the residuum from the sugar factory to the stable. There can follow thereby all kinds of stomach diseases and complications. Such cossettes should undergo a preliminary thawing before being fed.

According to Elert it is desirable to feed to animals a quantity of forage proportional to their percentage of water. The following per diem ration is proposed by Ahrens for horned cattle:

75 lbs. pressed cossettes; 2 lbs. oil cake; 5 lbs. clover hay; 2 lbs. chopped straw.

Rations for working oxen.

Briem recommends that working oxen shall receive 30 to 80 lbs. of cossettes per diem, depending upon the size of the animals. Under all circumstances it is desirable that the limit of the ration shall not be more than 8 per cent. of the animal's weight.

On some Austrian farms, oxen are worked for two or three months and then stall-fed for the market. In the spring of each year a number of beeves are purchased whose individual weight is never less than 1000 lbs. These are used for ploughing until December, and then fattened for 150 days. Summer fodder consists of grass with 2 lbs. corn, 2 lbs. barley ground and mixed with barley straw. During the early winter 88 lbs. fresh cossettes; later in the season the same amount of pulp from silos, instead of fresh cossettes. During the following period, and according to the animal's condition, there are given besides the above 7 to 10 lbs. corn ground with 11 lbs. hay. The resulting increase in weight is 20 per cent.

For oxen doing heavy work from January to May, on an Austrian farm, the ration was: Beet pulp 79 lbs., hay 19 lbs., chopped straw 4.4 lbs., crushed grain 4.4 lbs., malt sprouts 1.1 lbs., salt ½ lb. Oxen used at an experiment station in France, received a daily ration consisting of distillery pulp 88 lbs., hay 11 lbs., chopped straw 11 lbs., oil cake 6.6 lbs.

Ration for bulls on an Austrian farm: Beets 22 lbs., pulp 11 lbs., hay 4.4 lbs., clover hay 2.2 lbs., oats 1.1 lbs., chopped straw 9.8 lbs., straw waste 8 lbs., salt ¼ lb. Rations for live stock in general, as used in France: 1st. Diffusion pulp 132 lbs., wheat husks 8.8 lbs., corn flour 4.4 lbs., oil cake 4.4 lbs., flour siftings 4.4 lbs. 2d. Diffusion pulp 121 lbs., colza-oil cake 2.5 lbs., flour siftings 2.2 lbs., bean husks 2.2 lbs., wheat husks 2.2 lbs. 3d. Diffusion pulp 121 lbs., corn flour 4.8 lbs., flour siftings 4.8 lbs., oil cake 4.8 lbs.

Rations for sheep.

Sheep may be fed with cossettes when they are not being specially raised for their wool or selection for breeding purposes. Eight kilos. per diem per 100 lbs. weight is considered a desirable limit. To other sheep very little is fed, and some claim that cossettes should not be used at all for sheep feeding.

Ration for fattening sheep from January to May on an Austrian farm: Pulp 6.6 lbs., chopped straw 1 lb., hay ½ lb. Ration at an experiment station, France: 1st. Beet pulp 5.3 lbs.; hay 3.0 lbs., oil cake 0.6 lbs., barley ½ lb. 2d. Beet pulp 3.3 lbs., hay 4.4 lbs., bran ½ lb., oil cake ½ lb. For oxen doing very little work on an Austrian farm, the ration for 1,000 lbs. live weight, was: Beet pulp 55 lbs., fermented corn meal 44 lbs., crushed peas 1.1 lbs., crushed barley 2.2 lbs., malt sprouts 1.1 lbs., oat straw 5.5 lbs.

Ration for mules and horses.

The feeding of fresh pulps to horses and mules does not appear desirable in all cases. On some farms satisfactory results are obtained with 16 lbs. beets combined with 12 lbs. pulp and 12 lbs. chopped straw.

Another authority recommends that working horses, when stall fed, shall receive from 10 to 20 kilos. of cossettes per animal per diem, and when this amount is decreased the working power of the horse appears to diminish. Pubertz says horses may be kept in an excellent condition by a fodder consisting of 100 kilos. cossettes, 50 kilos. oats residuum, 50 kilos. hay, 20 kilos. rye bran. Ahrens, on the other hand, obtained excellent results by feeding to horses 90 lbs. of cossettes per diem.

Ration for pigs.

Numerous experiments show that it is a great mistake to feed more than 10 lbs. per diem of beet pulps to pigs. Under all circumstances the residuum must be combined with some other fodder. Experts justly maintain that the intestinal canal of swine is unsuited for the proper assimilation of refuse cossettes from the diffusion battery. In certain parts of Germany potato pulp from distilleries is combined in equal parts with beet pulps to form 3 gallons, to which is added 1½ quarts of crushed barley per diem.

A greater quantity than this limit brings about in swine a decrease in the quality of the fat and flesh, and in some cases results in a dropsical condition of their entire cellular tissues. Moreover, when such animals are fed with beet cossettes it is desirable that the product shall undergo a preliminary boiling or steaming so as to concentrate the same. It is desirable upon the whole, however, not to feed pigs with beet cossettes, although there are authorities who declare that the intestinal tubes of swine are admirably adopted to the assimilation of the constituents contained in this residuum (?).

Practical experiments by Simon Legrand during 94 days in feeding diffusion pulp to cattle gave the following results:

NINETY-FOUR DAY EXPERIMENT IN FEEDING DIFFUSION PULP TO CATTLE.

ITEMS.	Oxen.	Bulls.	Total.
Quantity of diffusion pulp consumed	620,400 lbs.	310.000 lbs.	930,400 lbs.
Cost of pulp	$705 00	$352 40	$1,057 00
Total cost of fodder	$1,188 00	$594 00	$1,782 00
Total cost of cattle and fodder	$4,197 60	$158 40	$5,781 00
Total selling price of cattle with no allowance for value of manure	$5,607 00	$2,319 80	$7,926 00
Total weight before fattening	46.640 lbs.	22,410 lbs.	69,080 lbs.
Total weight after fattening	58,700 lbs.	27,588 lbs.	86,328 lbs.

Mixing cossettes with other fodders.

Upon general principles it may be said there are important advantages to be derived in mixing cossettes with other fodders and arranging the combination in such a manner that the cossettes shall be 10 per cent. of the total weight of the animals fed in the case of oxen, and 7.5 per cent. in the case of sheep. These amounts are perhaps excessive. There are many authorities who recommend as an outside limit 4 per cent. of their weight.

Soured cossettes when given alone as a forage are not desirable, notwithstanding the fact that some experiments which have been made are rather encouraging in their results. Without doubt, from a chemical standpoint, there are certain constituents lacking to form a complete forage. They may contain nitrogenous elements in sufficient amounts, but this quantity is not sufficient to do away with other combinations furnishing additional nitrogen. The proportion between the nitrogenous and non-nitrogenous elements may be put down as 1:8. This, however, depends upon the condition one wishes to find the animals in after their feeding, and also depends upon the work they are called upon to perform. In the latter case it is well that this relation should be 1:5 to 1:6.5.

In all these considerations it is well not to lose sight of the physiological condition of the animals being fed. It is important to combine with the cossettes a certain amount of fibrous substances demanded by the intestinal canal. As neither the fresh nor the siloed cossettes contain sufficient albumin and fatty substances, these must be added by the use of hay, chopped straw, oil cake, etc. We do not put special stress upon straw or hay, for many residuums that may be obtainable on any farm, such as cereals, vegetables, etc., answer the purpose.

Rations for milch cows.

Eisben recommends the following rations for milk cows, per 1000 kilogs. live weight:

THREE RATIONS FOR MILCH COWS PER 1000 K. LIVE WEIGHT.

Kilos.	Kind of Feeds.	Per cent. dry substance. (Kilos.)	Dry matter contains			Nutritive ratio.
			Protein. (Kilos.)	Fatty substance. (Kilos.)	Carbohydrates. (Kilos.)	
5	Hay............	4.25	0.42	0.12	1.90	1:6.25
25	Cossettes........	3.12	0.28	0.02	1.81	
6	Summer straw ...	5.14	0.08	0.03	2.40	
6	Wheat balls.....	5.15	0.14	0.04	2.40	
1	Oil meal........	0.87	0.30	0.10	0.30	
5	Wheat bran.....	4.35	0.70	0.15	2.70	
48	Total.......	22.88	1.92	0.46	11.51	
3	Hay............	2.55	0.25	0.07	1.14	1:6.8
50	Cossettes........	6.24	0.47	0.05	3.62	
10	Barley straw.....	8.57	0.14	0.04	4.01	
4	Wheat middlings.	3.43	0.08	0.02	1.60	
1	Malt sprouts.....	0.90	0.22	0.02	0.43	
3	Wheat bran.....	2.62	0.44	0.10	1.62	
1	Oil meal........	0.87	0.30	0.10	0.30	
72	Total.......	25.17	1.90	0.40	12.71	
6	Hay............	5.10	0.50	0.14	2.28	1:4.9
30	Cossettes........	3.75	0.34	0.03	2.17	
25	Beet leaves......	5.00	0.50	0.17	1.50	
8	Cereal wastes....	6.86	0.11	0.03	3.21	
2	Colza oil meal ...	1.74	0.60	0.20	0.60	
2	Malt sprouts.....	1.80	0.44	0.04	0.84	
1	Bran...........	0.86	0.13	0.03	0.54	
74	Total.......	25.11	2.62	0.64	11.14	

When soured cossettes are used as a basis, they very materially increase the milk production which may possibly be explained by the action of amides upon the cells of the udder. Kellner and Andrä have noticed that forage beets may readily take the place of sour cossettes in the production of milk. These assertions must be taken with a certain reserve, as they are certainly in contradiction with the observations made by other well-known authorities. Furthermore, the nearer the beet approaches the turnip the more characteristic will be the flavor imparted to the milk of the animals fed. Again, there is always a certain danger of acid fermentation arising in the stomach.

The last of these rations is proposed for oxen and cattle being fed for a stock yard. It is evident that all these proportions may be modified by the local conditions, the outcome of the experience of the cattle raiser. The farmer himself has at his disposal the vast number of combinations of forages based upon Wolff's tables, giving the average composition of such forages.

Digestibility of residuum cossettes.

The data published respecting the digestibility or assimilation of albuminoids contained in the residuum cossettes varies considerably. According to Henneberg it is only 45.01 per cent., but this average is entirely too low. Morgen declares that the average is 76.03 per cent. for the pancreatin and pepsin combined, which in reality corresponds in a measure to the average of digestibility of the albumen in sugar beets. Regarding the non-nitrogenous elements, Henneberg declares that the average digestibility should be at least 84 per cent. This data demonstrates beyond cavil that the forage under consideration has a nutritive value which under no circumstances should be overlooked, and consequently all efforts for its utilization are certainly justifiable.

Cossettes as food for man.

It is interesting to recall the various attempts made at its utilization in the alimentation of human beings. It is mainly to the poor provinces of Bohemia and Poland that we refer, where the struggle for life is such that any commodity having a nutritive value at a reasonable price may be used. For example, Fricke kept with salt, for a long period, white cabbage and beet cossettes that had been previously boiled and washed. After an interval of four months this combination still possessed an excellent taste and could be eaten after being properly seasoned with oil and vinegar.

Ottocar Cech says that in Bohemia the cossettes are first washed in cold water to free them from sand and dirt; they are then allowed to ferment during a period of two or three weeks. Under these conditions the final product has an excellent flavor and odor, and when combined with caraway seeds is most palatable.

On the other hand Naprivil combines with the residuum cossettes a certain amount of beans and also lentils in order to vary the nourishing combination. Under these circumstances there was realized an equilibrium, so to speak, between the legumen of this vegetable and the hydrocarbons of the cossettes. A mixture of equal weight of lentils with sour cossettes gives, according to this authority, a nutritive combination which is possessed of great digestibility. Hard beans ground to a flour and put with the cossettes give a mash which is better yet.

Cossettes as food for game.

In Germany, at Königstein, Hamburg and Usingen, experiments have been made in feeding game with residuum cossettes. Hare and deer eat this product only when forced to do so.

Experience shows that it is not desirable to allow the animals fed during winter, when their stomachs are full of cossettes, to remain for too long a time without a reasonable amount of exercise. Cold necessarily paralyzes the activity of the stomach and might result in complicated diseases that always mean death.

What residuum cossette feeding means in Germany.

From an economical standpoint the utilization of sugar-beet residuum cossettes as a forage has an enormous importance. Germany, where the annual out-put is ten millions of dollars, is an example of this. If one makes a calculation using well-known, established data, the value of this product, based upon its chemical composition, would reach forty millions of dollars for the Empire. If one were to consider only the fertilizing value of its constituents, this more than represents the market value of the residuum, as it is now recognized. Under these circumstances it becomes evident that the tiller or farmer of the United States makes a great mistake in not recognizing what he has within his reach.

Siloing Residuum Cossettes.

Silos for reducing cossettes.

It is possible, under most circumstances, to consume entirely the residuum cossettes of an average beet-sugar factory immediately: that is to say, to consume them in their fresh condition as they leave the cossette presses. This, from many standpoints, is very fortunate. In the first place, the transportation of the residuum means a large increase of work for animals and individuals occupied in agricultural pursuits, during the autumn, at the very time when crops are harvested, and many farm duties, such as ploughing of the land, etc., should be thoroughly attended to.

The factories working under the best arrangement generally have a number of oxen to feed, and it is well to have a determined amount of diffusion cossettes placed in silos at the factory. Such silos are usually of the very best types.

In general, our changeable American winters are disadvantageous to beet-residuum conservation, and attention to its proper preservation is of greater importance than in Europe. When building a silo, the very best material should be used; and as there is considerable lateral and vertical pressure, the side-walls should be sufficiently thick to offer the desired resistance; corners should be filled in with triangular or rounded bricks.

For many years it was argued that diffusion pulps could not be kept in silos lined with bricks; experiments have shown such theories to be erroneous. Cossettes remaining for five months in silos thus constructed lost only 8.9 per cent. of their dry substances.

It is customary to pile the residuum cossettes in carefully-constructed ditches lined or not with masonry and cement. There are advantages especially to be derived by the use of elongated silos, so that the portion exposed to the air during their opening shall be as small as possible in order to reduce to a minimum the amount that will subsequently rot through oxidation. The dimensions, such as length, depth, etc., as recommended by various recognized experts, are extremely variable.

As the most desirable types of silos for residuum beet pulps are expensive, they are not within the reach of the average farmer. When beyond a certain size they must be cement-lined.

Pellet and Lelavandier recommend that the length be 75 feet, width 12 feet, and depth about 4 feet. These dimensions vary with the conditions one may have to contend with. As to the depth, there are no difficulties in the way, provided the soil is not damp. It is not desirable to reach a depth where sub-strata water currents may be met. The other arguments that may be brought forward are based mainly upon the various conditions that different environments create. It is very exceptional, however, that the depth of silos exceeds six feet. Sometimes very deep silos, say 9 feet, give good results; the pulp then eliminates considerable water by its own weight.

In certain cases, the size is regulated so that a wagon may turn upon itself in the silo, which calls for a width of at least 15 feet. In agricultural attempts at siloing this width is frequently reduced to three feet. The width of the silo must vary with circumstances; if too great, its covering would offer some difficulty. However, the width should never be less than that of an average cart.

It is recommended that the bottom of the silos be paved in such a way that there shall be two-thirds of an inch per yard slant from the entrance to the exit, with the view of facilitating the flow of water that runs off from the cossettes. In certain cases it has been found that this slant should be double, thus permitting the flow from the right as well as the left. Under these circumstances there is no deposit of water at the bottom of the silo, and stagnant water of any kind would soon contaminate the mass of the residuum. Sometimes it has been found an advantage to carry off the water filtration by certain drains; it has also been proposed to allow this water to collect in special wells, filled with stones or other material, from which, when the occasion presents itself, it may be pumped out. On the other hand, some experts advocate the building of these silos on porous soil.

Complaints respecting characteristic odors of butter made from milk of pulp-fed cows, refer to siloed pulp. The residuum has become acid and undergone certain organic changes during its keeping, due frequently to the contamination caused by badly drained silos. It is important to call attention to the fact, that the drainage-water does not contain more than a slight fraction of the nourishing elements of the cossettes; its composition, according to Vivien, is nitric elements .0020, carbohydrates .0270, potassic substances .0006, various mineral substances .0052, water and acetic acid .9818.

It is to be noticed that the bottom paving of a silo materially helps the conservation of the siloed cossettes, and experience has shown that for a silo of average dimensions all lateral walls, brick or otherwise, are unnecessary, as they render only a very secondary service, mainly so when in especially plastic soils.

Herzfeld says that the slope of the silos is of secondary importance, and that the transformations that occur in the mass being kept depend mainly upon the degree of dryness of the products upon leaving presses.

On the upper level of the silos it has frequently been found that certain economical advantages may be derived by the introduction of small cars, of the Decauville type for example, traveling over the silos on narrow gauge tracks. This arrangement allows one to carry the residuum cossettes rapidly and under very economical conditions from the factory to the ditch or silo in which they are to be kept for a period of months.

Filling silos with beet cossettes.

Silos should be filled during cold weather and the filling of each silo should not last more than three days. In our climate the beet-sugar campaign frequently commences before frost sets in, so that the filling would take place at the wrong period; it would be better at first to feed direct to cattle. Farmers should not forget that filling during warm weather means very inferior fodder later in the season. Care to have the mass of pulp perfectly uniform, so as to prevent air being imprisoned, is very essential, as its influence is very destructive. It may be compressed as much as possible with the back of the spade or other flat instrument used in filling. Tramping upon the residuum by walking a horse or cow over the product during filling is a very common custom, and covering the bottom of the silo with several inches of chopped straw is a good practice the advantages of which are numerous. Alternate layers of pulp and straw are to be recommended only in certain cases. The writer is rather in favor of alternate layers of salt and residuum. One man's labor for filling and emptying a silo of 5 ton capacity is sufficient.

Silos are generally open on top. Experience has shown, however, that advantages are to be derived from resorting to a covering of at least two feet of earth, in order to prevent the action of air and putrefaction. When crevices open, due to the settling of the mass, they should be closed as soon as possible.

The cossettes are placed in silos so that the top (we refer to the portion above ground) shall form slanting angles of about two feet, which will materially contribute towards pressing the mass of matter beneath. The slanting sides above ground should be gradually covered with earth, the latter being beaten down with care. After an interval of several days, this outer covering being well settled, another layer of clay is added under the same conditions.

Various coverings for the top have been suggested, such as defecated scums, ashes, etc., but earth seems to be the best of all. If proper attention be not given to the question of covering, putrefaction will continue from the surface to a depth of two feet during a severe winter; but if properly covered, the pulp may be found in an excellent condition two inches from the surface. It is to be regretted that some of our farmers have used straw instead of earth; this is the very worst material they could select for the purpose. Heavy weights on the top have some advantage, but the best of all, as before mentioned, is earth; this can be several feet in thickness, and its weight upon the pulp will be all that is desired.

Experience has shown that when the silos slant from bottom to top, considerable advantages are found as far as the keeping qualities of the residuum are concerned. Silos when filled settle about 10 per cent., and it is to be noted that the settling has considerable importance, for the simple reason that a given volume of the product, before and after, means an economy as regards the cubical contents of the silos.

It is very advisable, in order to obtain the best results in cossette keeping, especially during the period when they are withdrawn from the silos, to sub-divide the various chambers in which the product is kept into several compartments. These separations are made at different points in the direction of the least dimension by suitable walls of stone or earth, in such a way that even when one of these divisions is entirely open it in no way interferes with the adjoining one. Under these circumstances it is possible to arrange so that the supply for the day may be sufficient to meet any possible emergency, and in no way have an influence, as far as atmospheric action is concerned, upon the product being kept in the adjoining section.

Transformation during siloing. If one leaves fresh cossettes exposed to the air there follows a putrefaction after a very short time. Notwithstanding this fact, very often when the factory method of washing does not allow the construction of any special silos, and when the farmers refuse to undertake it, the product is simply thrown in piles and left exposed to the air. Under these conditions it becomes evident that the factories must lose, or in other words make a sacrifice, which under better management would have been unnecessary, of a product that enters very materially into the financial profits of the season, when the entire bulk of the sugar campaign is considered.

This organic transformation, or putrefaction, even during siloing, may represent a sacrifice of 30 to 50 centimetres in depth, meaning a considerable proportion of the total product. It becomes evident that the essentials for the proper preservation of these cossettes consist in keeping out the air and rain. This distinctive action of rain and air increases with the period of keeping, for the reason that the cells of the residuum thus stored become, with time, more and more open. The rain entering carries away a large percentage of the nourishing elements.

Do what one may, there always follow numerous transformations in the silos; there arises a fermentation in the mass of all, or nearly all, of the organic substances, such as the non-nitrogenous, which are partly converted into lactic acid. Under these circumstances the cossettes are possessed of a decidedly acid reaction and may contain, according to Morgen, more than 4.7 per cent. of their dry substances as organic acid, calculated upon a basis of lactic acid. This apparently abnormal quantity has very much less influence on the digestion of animals than one might be led to suppose. They give, on the contrary, a rather agreeable characteristic sour taste, to which cattle soon become accustomed, and furthermore they appear to eat the product with great avidity.

But, it is to be noticed, that in order that the cossettes may undergo this lactic fermentation to the best advantage, they should reach a temperature of very nearly 40° C. [104° F.], without any supplementary heat other than that found in the siloed mass, otherwise there would follow an objectionable acid fermentation, under which circumstances, instead of lactic acid, there would be found a micro-organism known as mycoderma aceti, that would soon show its activity, resulting in the formation of acetic acid, for which live stock in general have a distaste. Certain cattle absolutely refuse it under any and every circumstance, and the product then has absolutely no commercial or feeding value.

As the temperature in the silos is considerable, it should be measured with a thermometer and controlled. Experiments have been made to collect some data regarding temperature in silos filled with two kinds of pulp, and the difference in heat evolved after some time was remarkable. A comparatively high temperature is generally desirable, for the reason that it shows that fermentation has commenced.

As regards the nitrogenous substances, they also undergo most important transformations. They tend to become very simple compounds. For example, the albuminoids are transformed into amides. Morgen thus finds in the analysis of soured beet cossettes 24.03 per cent. of nitrogen in the form of amides. It must not be overlooked that the average for these amides for the entire mass was not more than 8.08 per cent.

On the other hand, pressed fresh residuum cossettes do not contain even the slightest trace of these substances, which is explained by the fact that they rapidly diffuse into the juices during the process of diffusion in the battery.

As the most recent investigations show that amides have the same nutritive value as carbohydrates, they are consequently very inferior to the nutritive equivalents of albuminoids, from which they are derived. Under these circumstances there is evidently a loss at the expense of the nitrogenous elements. There is, furthermore, another loss, which this time is very direct. During siloing the cossettes settle and allow the liquid in suspension to run off, carrying with it a considerable percentage of substances that have important nutritive value.

In all silos it necessarily follows that during the fermentation the hydrocarbons undergo alterations, and there will be formed an acid of the fatty series and also carbonic acid.

Morgen has shown that in the gases that appear to be imprisoned in the upper layers of the cossettes, there exists 3.5 per cent. of anhydrous carbonic acid. Under these circumstances one obtains a mass that is grayish in color, with here and there certain spots of more or less blackish appearance, pasty in texture, and after a reasonable period no longer possessing the characteristics of the original pressed residuum, all its primitive structure, organic, etc., having disappeared.

The principal centers for change in silos are along the sides and in corners; and no well-built silo should have angular corners, otherwise a thorough cleaning when emptied would be impossible. The shape of a silo has consequently an important influence upon the keeping of the cossettes; most experts say that the sides should be vertical, so that there will be a regular pressure of the pulp by its own weight. The writer much doubts if vertical sides accomplish all that is desired; an inverted truncated pyramid would be better. No experiments have been made in this direction, so it should not be attempted unless there be in advance some certainty as to results.

According to Liebscher, fermentation diminishes after the sixth day of siloing, and when the fifteenth day is reached the temperature of the mass undergoes little or no change, and is about the same as that of the ground in which the ditch has been made. These transformations, as regards the chemical composition of the products, are shown in the table which follows, as given by Maercker:

EARLY CHEMICAL CHANGES DURING SILOING (MAERCKER).

Constituents.	Fresh pressed cossettes.	Dry matter.	Soured cossettes.	Dry matter.
Water....................	89.77 per cent.	——	88.52 per cent.	——
Dry matter..............	10.23 "	100.00 per cent.	11.48 "	100.00 per cent.
Ash.....	0.58 "	5.67 "	1.09 "	9.5 "
Fatty substance	0.05 "	0.49 "	0.11 "	0.95 "
Cellulose	2.39 "	23.36 "	2.8 "	24.39 "
Nitrogenous substances.	6.32 "	61.78 "	6.41 "	55.84 "

From this data one may conclude that during the keeping of the residuum its percentage of dry substances, such as ash, fatty constituents, cellulose and nitrogenous elements, is materially increased. Whilst this increase is true as regards the fatty constituents (it is to be noticed that albuminoids under certain conditions, through decomposition, can give fatty constituents), this phenomenon is very misleading as far as the other compounds are concerned, for the simple reason that there is a certain water percentage which has been lessened, and there consequently follows a corresponding increase in the dry substances. It is well to understand that there has not been a corresponding loss of these dry constituents, for whatever may be the loss of these it is never proportional to the losses of watery vapor, whatever they may be. While the loss of water may be 40 per cent., it does not necessarily carry with it 40 per cent. of different compounds forming the actual constituents of the cossettes proper, which fact may be noticed by the relatively increased nutritive value of the material. The fact is, that the actual analysis of soured cossettes shows the material advantage of submitting the fresh product to some siloing. Gradually, as the period of their keeping progresses, this phenomenon, or transformation, so to speak, becomes more and more pronounced, as the analysis of Petermann evidently proved.

CHEMICAL CHANGES DURING PROLONGED SILOING (PETERMANN).

Constituents.	Cossettes after 8 months' keeping.	Dry matter.	Cossettes after 2 years' keeping.	Dry matter.
Water...........	87.8 per cent.	——	83.98 per cent.	——
Dry matter......	12.2 "	100.00 per cent.	16.02 "	100.00 per cent.
Ash.............	1.02 "	8.36 "	2.96 "	18.48 "
Fatty substances	0.08 "	0.65 "	0.74 "	4.62 "
Cellulose........	2.67 "	21.89 "	5.06 "	31.59 "
Albuminoids ...	1.00 "	8.2 "	1.83 "	11.42 "
	(Organic nitrogen) 0.16 per cent.		(Organic nitrogen) 0.29 per cent.	
Carbohydrates .	7.43 "	60.9 "	5.43 "	33.89 "

Unfortunately the keeping in silos of a product such as this necessarily means a considerable loss, that in certain cases amounts to from 40 to 45 per cent., do what one may, and one must make the best of these conditions. Notwithstanding the fact that the residuum may be kept for a longer period and may undergo considerable organic changes, it may always be utilized to advantage in cattle feeding.

During the Franco-Prussian war in 1870, it was to be noticed that in Germany there was a marked decrease in the number of cattle, and for a time there were certain fears entertained that it would be impossible to find means of getting rid of the enormous quantity of residuum cossettes that were left after the sugar campaign. These arguments were very misleading, for the simple reason that the product was properly siloed not only by the farmers but by the manufacturers, and while practically only used in some cases two years afterwards, extraordinary benefits were derived from this practice. The total number of head of cattle soon became normal, but as the consumption at first was comparatively small there was necessarily an increased demand for fertilizers, which consequently brought to light the possible fertilizing value of this residuum.

Dohrn has also kept this material for a year and a half, and was perfectly satisfied with the results he subsequently obtained in feeding.

Unfortunately these organic losses during siloing are not the only ones to be considered. The analysis shown above would lead one to believe that there has resulted a certain amelioration, which in reality does not exist. On the contrary, digestion experiments according to the methods of Stutzer, while they do not prove very much, claim to show that there is a mistake in supposing that the siloed cossettes are improved after a prolonged keeping.

Experiments by Morgen show that the digestibility of nitrogenous substances is 83.2 per cent. for the soured cossettes as compared with 76.3 per cent. for the fresh cossettes. Saillard's experiments show that the digestibility for the siloed cossettes is only 73 per cent. But all these investigations prove nothing as regards the condition in which the nitrogenous substances exist in the residuum, for the simple reason that a certain amount of these constituents consists of ammonia, the nutritive value of which may be considered nil. Regarding these losses different authorities, adopting numerous modes of siloing, have arrived at very different results.

The variation of these data may be mainly explained, especially in the case of Maercker, by the fact that in these observations all the decomposed cossettes have been deducted from the calculations as having no feeding value. Under these conditions there is an important margin of variation that is open to discussion.

The experience of Liebscher shows that it is possible, from a practical standpoint, to reduce these losses very materially by certain precautionary measures. Herewith are his observations for a period of keeping lasting 108 days:

Stone silos with stone covering, total loss 7.3 per cent.

Stone silos with earth covering, 6.5 per cent.

Cemented silos with stone covering, 6.7 per cent.

Cemented silos with earth covering, 5.2 per cent.

It is difficult to reconcile this data with the assertion of Maercker, who declares that with the best-arranged silos these losses cannot be brought below 20 per cent. The truth is to be found between the two extremes of these and other authorities.

It has been recommended that, in order to diminish the losses, one alternate in the silos successive layers of other substances than cossettes, so that there follow in regular order hay and chopped straw, or other forage capable of absorbing the liquid running from the residuum and thereby preventing these losses.

According to Rabbetge, it is desirable to mix with the cossettes 5 per cent. of chopped straw. Von Ehrenstein declares that besides the virtue the straw has of absorbing the liquids, it possesses the advantage of undergoing a transformation in the silos which in reality increases its digestibility.

Pellet and Lelavandier have demonstrated that besides the advantages of straw just mentioned, it penetrates the mass and becomes rapidly heated, and under these circumstances attains within a very short time the requisite temperature for satisfactory fermentation. They recommend that at the bottom of the silos there be placed about one inch of chopped straw, then three to five inches of cossettes, then one inch of straw, etc.

Strange as it may seem, a German authority declares on the contrary that the losses are greater with straw than without it, and this assertion seems to be endorsed by many of the leading authorities who state that with straw in the silos the mass undergoes considerable loss of dry substances.

Mixing of pulp with molasses is practiced by some farmers; the sugar thus introduced is soon converted into alcohol and carbonic acid. The fermentation is very active and must be watched. Excess of alcohol in pulps may in certain cases be very objectionable. Just whether the sugar added does facilitate keeping remains to be demonstrated.

Other investigators have endeavored to establish a very radical method. They attribute all these losses to fermentation, and attempt to do away with it entirely. They apparently justly declare that such losses are not justifiable, even when making allowance for the advantages gained, such as giving to the cossettes all the qualities of taste that cattle seem to relish. They go so far as to propose to mix the residuum with some antiseptic, such as salicylic acid or borax ($\frac{1}{8}$ oz. of borax per 100 lbs. cossettes). The results obtained were no more encouraging than those realized by the addition of lime or salt, which has the opposite object in view, that is to say to actuate the fermentation. Lime helps the fermentation by the formation of butyric acid, which gives to the cossettes, however, a disagreeable flavor.

All chemical substances added to cossettes have but the effect of putting them into such condition as will cause them to be rejected by the animals to which they are fed.

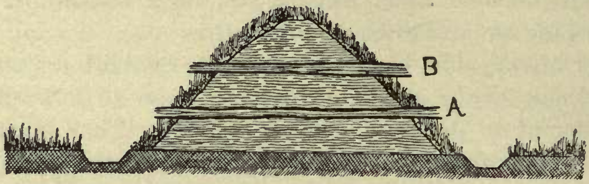
Surface siloing.

It may be admitted upon general principles that the cossette residuums will be possessed of keeping powers provided the water they contain can drain off, and that the product be well protected from the rain and variations of the exterior air. A very simple arrangement for surface siloing is shown in Fig. 10. On each side of the pile are suitable ditches that carry off the dripping water from the moist pulp; the earth covering is taken from the ditches. *A* and *B* show layers of straw projecting beyond the sides, and these act as drains from the interior.

The system of surface storing of beet cossettes as it exists at Alvarado, in connection with the silos and the dairy, is fully described in a bulletin of the California experiment station. There is a large trestle that carries the beet residuum from the factory and drops it into the silo below.

"The silo is 460 feet long, 80 feet wide and 8 feet deep. It is floored and sided with two-inch planks, and the sloping sides are supported by heavy posts, set in the ground and braced with strong timbers. Three tracks run through the silo, one on each side and one in the centre, on which a car is drawn by a horse to carry the pulp to the cattle barns several rods distant."

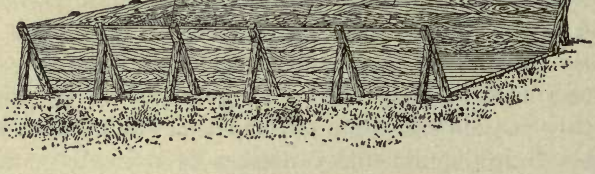
Fig. 10.



Simple Style of Surface Siloing.

Another silo built on the same principle is shown in Fig. 11. This may be made of the roughest sort of lumber, and of any size to suit the convenience of the feeder. This silo is 12 feet wide, 30 feet long and 6 feet deep, and will hold about two car-loads of cossettes.

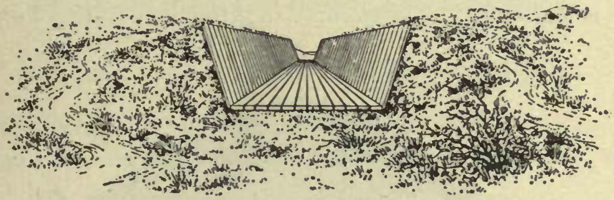
Fig. 11.



Surface Siloing Using Lumber.

Figure 12 represents a simple and cheap way of constructing a silo by excavating a passage through, or in a hill. "The bottoms should be planked in all such cases and means provided whereby the water draining from the cossettes may be easily and quickly carried off. The planks should, therefore, set well up from the ground and be far enough apart to leave a crack between them after they have swelled with the contact with moisture from the cossettes." This silo may be made of any desired size. One used by a well-known feeder is 600 feet long, 50 feet deep, 20 feet wide at the base and 80 feet wide at the top. The bottom only is planked, and has gutterways under the floor, so as to thoroughly drain the cossettes. The silo is filled by means of carriers bringing the residuum directly from the sugar factory to the upper part of the silo when the carrier is dumped. In the small silo shown in the figure the filling can be done by driving the wagon alongside the top of the silo and shoveling the cossettes into it. Satisfactory results have been obtained in France with the wood-built silo shown in Fig. 13.

FIG. 12.

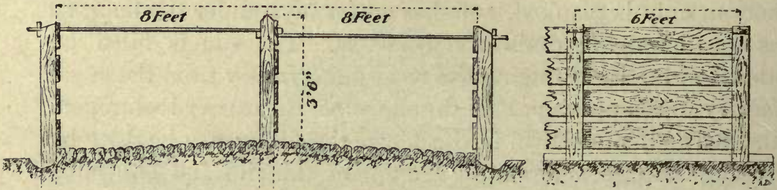


Silo Formed by Excavating Hillside.

Just within what limits this is suitable to our cold climate experiments alone can determine; on the other hand, for California, the method would be excellent. Silos of this type are 90 to 100 feet long by 12 to 16 feet wide and 3 feet 6 inches in height. The bottom is made of stones placed on end, with sufficient grade to carry off the water from the mass of pulp into lateral drains communicating with a special manure pit. Wooden posts, seven inches square, penetrating the ground at least 12 inches, are placed vertically at intervals of six feet; these are held in position horizontally by iron bars ½ inch in diameter, which overcome any lateral pressure.

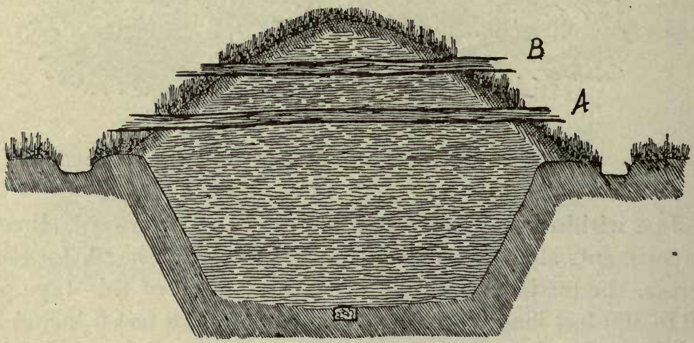
The sides of the silo consist of boards 12 x 1 with an interval of one inch between each, and all should have a thick coating of tar. To facilitate filling and assure keeping the mass in good condition, the silo is divided in two parts by a partition of posts and boards. The silo may be filled by use of a wheelbarrow from a plank slanting up from the ground; the iron braces are placed in position gradually during filling, and withdrawn as the silo is emptied. The capacity of a silo of this type is 300 tons. It is claimed that the loss during keeping is very slight, as excessive fermentation is not to be dreaded, owing to the facilities offered for drainage between the boards and at the bottom.

Fig. 13.



Surface-Built Silos for Beet Pulp as used in France.

Fig. 14.

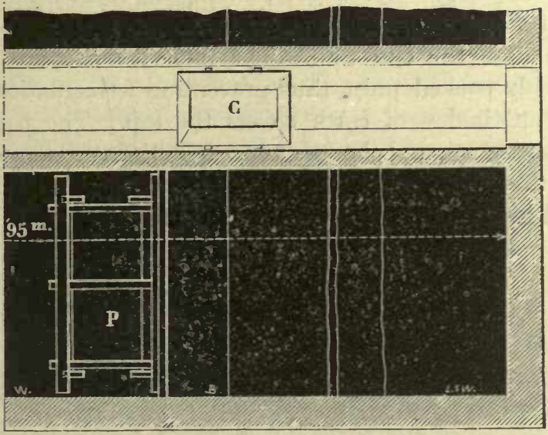


"Dug-Out" Type of Silo.

A curious custom of some farmers is not to cover the pulp, but simply to keep the upper surface level; the entire mass is then used just as it is, after having been exposed to the air for a period of months.

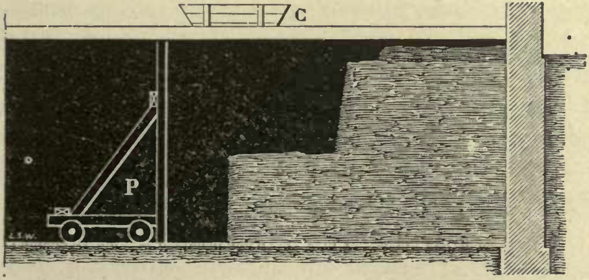
Silos beneath the surface of the ground are very variable in shape, size, etc. A very simple dug-out type that has met with considerable practical success is shown in Fig. 14. The drainage consists simply of a few small stones. The water from the portion above ground drips through the straw layers *A* and *B* into the side ditches from which has been taken the earth covering.

FIG. 15.



Horizontal Section of Underground Silo for Beet Pulp.

FIG. 16.



Vertical Section of Underground Silo for Beet Pulp.

A most interesting, well constructed type of underground silo of 4,000 cubic meters capacity intended for distillery beet residuum was seen by the writer at the *Ferme de la Briche*, France. The refuse is carried from mash tubs in cars *C* (Fig. 15), in which it is mixed with chopped straw, hay, etc. A movable partition *P* (19.68 × 11.48 feet), having the exact dimensions of the silo's cross section, is mounted on wheels and placed a short distance from the end wall. The intervening space is filled with closely packed pulp, thus preventing fermentation, and a layer of 10 inches of earth covers the top. The partition is moved backward, and the foregoing operations are repeated. It is said that beet pulp, under such conditions, will keep for years; it is taken from the silo in vertical slices.

CHAPTER II.

Dried Residuum Cossettes.

Upon general principles fresh or siloed cossettes, considered as a forage, entail certain complications in connection with their feeding, keeping, handling, etc., hence there must necessarily be some advantages in their drying.

Early efforts.

The first really serious experiments made in this direction were those of 1878, by Blossfeld, who at that period had conducted quite a propaganda for the encouragement of the idea of cossette-drying that he had been expounding, and the necessity of discovering some practical means for overcoming the many difficulties involved. This idea was not well understood by the German farmers and sugar manufacturers until 1883, when a prize of fifteen thousand marks ($3,750) for some practical solution of this question was proposed. In order to make the question thoroughly clear in the eyes of those interested in the subject certain conditions were stipulated, viz.: The dried pulp should contain only 14 per cent. water, about the same as hay—it should be without any perceptible odor, and not burnt during drying; the loss of nutritive elements should not be more than 8 per cent.; the expense must not be more than about 2½ cents per 100 lbs. of pressed cossettes used.

Prize for a dryer.

Buttner and Meyer were awarded this prize, and their apparatus, which has actually a great practical value, was the starting point for the realization of an idea that has since been of considerable importance to the would-be feeders of this beet-cossette residuum the world over.

Objections to using dried cossettes.

Since then numerous installations of this plant have been made, and these continue to increase in number. It must be said that from the start when this dry product was introduced upon the market, it met with much opposition from those who had occasion to avail themselves of this valuable forage, and it was frequently looked upon with a certain misapprehension. The arguments advanced showed that a very indefinite idea was possessed by those discussing the question, and for this reason they need not all be mentioned here.

It is interesting, however, to call attention to the farmers' assertion that it was paradoxical to assert that a handful of the dry product could have the same nutritive value as a bucketful of the moist substance from which it was made. These arguments occasioned numerous agricultural gatherings at which the entire question was discussed upon a very practical basis. The rural press of the country took up the question and the actual outcome has been that dried cossettes are now considered as a staple commodity upon the German market.

The principal promoters.

To Maercker and Morgen is justly due the credit of having put aside, through their numerous publications, all the erroneous assertions of many of the would-be scientists who attempted to cry down this valuable product.

Before mentioning exactly in what the practical solution of cossette drying consists, it is important to insist upon the necessity of these cossette dryers producing a product which shall contain the greatest profitable proportion of dry substances; and from this standpoint one may notice that since the cossette desiccating appliances were first introduced, the percentage of dry matter contained in the pressed cossettes has risen from 12 per cent. to 16 per cent., which means that there is 30 per cent. less water to be evaporated than there was formerly, this phase of the question representing considerable fuel economy.

Limit of pressing.

In the chapter devoted to siloed cossettes, we discussed the efforts made to reduce the water in pressed cossettes and consequently to increase the percentage of dry matter. The limit of 16 per cent. should not be exceeded for the simple reason that there would always follow a considerable loss of dry substance in the sweet water running from the presses. No solution other than the customary pressing has been found.

When one considers the enormous volume of cossette residuum leaving the average beet-sugar factory, it will be seen that it would be by no means practical to run this product through hydraulic presses, as once suggested. With the modern cossette presses there would be no advantage in pushing this pressure beyond the limit it now attains, when drying is the object in view, as practical experience shows that when this pressure has attained a certain crushing limit, drying them is next to impossible, as the heated gases that are in such furnaces cannot accomplish the object in view. They would carry with them during their circulation a large percentage of the finer particles of which the product consists.

Liming before drying.

Buttner & Meyer some years since forced the cossettes through perforated cylinders combined with a slanting spiral arrangement which was in close communication with another receptacle containing milk of lime, in which the residuum became saturated with lime. It was subsequently strained before leaving the upper parts of the cylinder.

Without doubt, lime has great influence upon the cellular texture of the beet slices being treated, and will often permit a greater percentage of water to escape; but independent of certain mechanical complications that we need not mention here, there is always danger of hardening the cossettes. It frequently happens that the fuel used for the drying in this appliance contains sulphur. The gases of the furnaces will then be saturated with anhydrous sulphurous acid, which, coming in contact with the lime of the cossettes during their working in the Buttner & Meyer dryer, would result in a certain calcic deposit.

Herzfeld called attention to the fact that after a reasonable period of keeping, this dry residuum threw out sulphuretted hydrogen, notwithstanding the fact that it contained almost insignificant traces of this chemical.

At the present time, liming of residuum cossettes has been practically abandoned, and there remain now only the natural, dry cossettes, which product is becoming yearly more and more popular.

Hot diffusion facilitates pressing.

As the emptying of the diffusors of the diffusion battery may now be automatically accomplished, the battery may be worked at a high temperature. This greatly facilitates pressing, as it is practically shown that cossettes lose, during their pressing when hot, a greater percentage of water than when pressed cold.

Such being the case it becomes imperative to re-heat this residuum in the diffusor, which operation becomes possible by using hot water, and to carry the product as simply and as quickly as possible to the cossette presses.

The Pfeiffer compressed-air mode for employing the diffusors is certainly very practical in its working. Besides the direct advantages of hot cossette pressing, there is a direct fuel economy, as the residuum is introduced into the dryer in a warm condition, resulting in that much gain in the caloric which must be furnished to accomplish the desired drying.

Waste gases for drying.

Drying may be most economically accomplished by using the gases escaping from the grates of the boilers, and which combine with the gases in the special generators. It is claimed that there is thus produced an intense gas circulation, which is very favorable to the residuum desiccation, without danger of cooling or any loss of heat. It is claimed furthermore that during this special drying the cossettes will not absorb any of the gas combination, as the water they contain must increase 1700 times in volume before becoming steam, and that under these circumstances there is created a current of vapor sufficiently violent to prevent any direct contact between the cossettes and the gas proper.

Experiments have shown that to properly utilize this lost heat from the boilers would necessitate the building of a very large and expensive appliance. Furthermore, steam boilers are rarely arranged as they should be, and an enormous amount of gases is always liberated from them that cannot be utilized, and that is unfortunately supersaturated with soot, their working, moreover, being very irregular.

The construction of a special furnace for accomplishing the object in view, is the main point on which our attention should be centered. It has been found desirable to obviate the contact of the gases with the residuum cossettes, in order to prevent their contamination. All combinations that have thus far been devised are not very serviceable in their general working, from an economical standpoint, for the simple reason that there always follows an enormous loss of heat through radiation.

Utilization of lost heat for drying.

It has frequently been suggested that for the drying of cossettes, the lost heat from the various appliances of sugar factories should be used. Investigations in this direction have been centered upon the utilization of the supposed latent heat, but up to the present time the results obtained have been by no means encouraging.

On the other hand, many experts have denied the existence of stored-up heat of evaporation, because they believed that in order to evaporate the water of the heated cossettes in the furnace it was sufficient to circulate air in the drier, which, owing to its natural hygroscopic power, would become supercharged with the watery vapor. A fact that has been apparently overlooked is that a complete realization of this phenomenon would have necessitated a supplementary expenditure of caloric. Finally, experiments were made to utilize the caloric contained in the water evaporated, in the same way as this is realized in evaporating appliances, such as triple and multiple effects as used in the sugar factories. The substance here dealt with is, unfortunately, not as fluid as is beet juice, and all facts considered it is difficult to arrange an apparatus, or combination of appliances, that would meet all the numerous demands of beet cossette drying. The transfering of the cossettes from one receptacle to another cannot be accomplished with the same ease as is possible when handling liquids. In order to overcome this difficulty it has been proposed to reduce cossettes to a sort of paste. Furthermore, the cossettes have not the same contact with the heating surface of the evaporator as is possessed by liquids, and the co-efficient of heat transmission falls very low. The multiple effect mode of desiccation would demand appliances of a stupendous size.

Rational appliances led to poor results.

All efforts to apply the rational principles of economy in this operation of cossette drying have failed, and, strange as it may seem, the most irrational apparatus yet devised has apparently led to the most practical results. The rational application of heat, based upon the principle of counter currents, in which the cossettes will come in contact with gases of an increasing temperature, was not successful, for the simple reason that the residuum was burned.

The inventions to overcome this difficulty are extremely numerous and could not be even mentioned in this writing. We shall center our attention on three appliances, which are

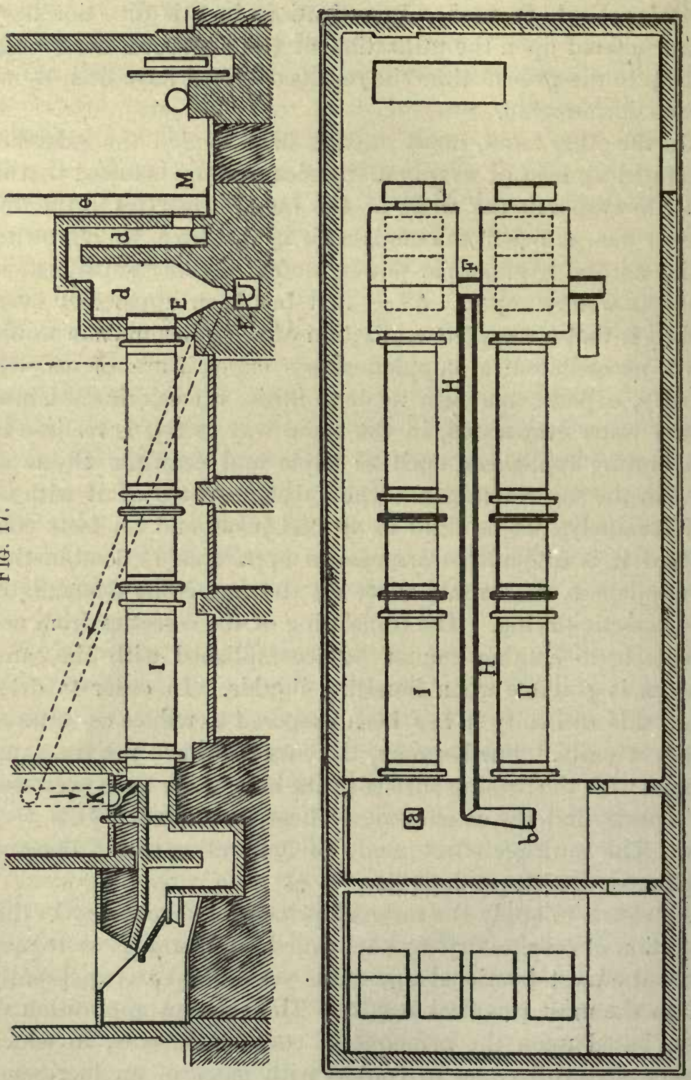


Fig. 17.

Elevation and Plan of the Mackensen Dryer.

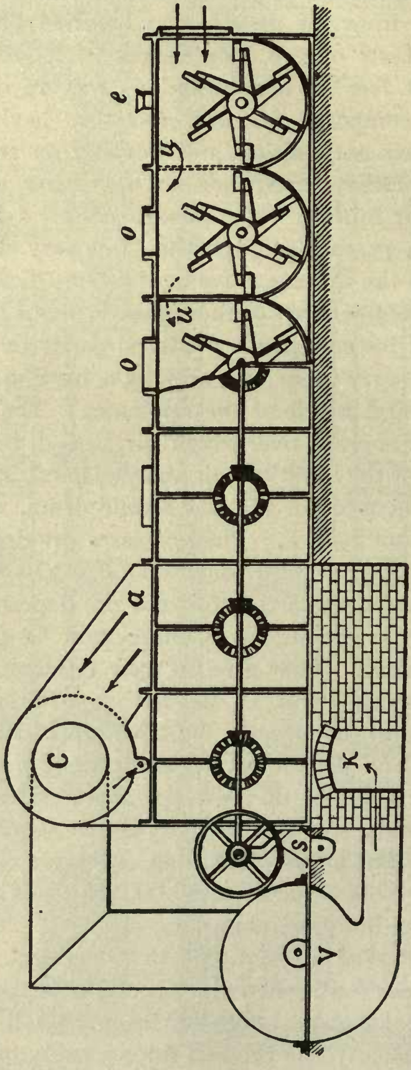
considered to be standard and practical in working. These are the Mackensen, the Petry & Hecking and the Buttner & Meyer.

Mackensen dryer.

With the Mackensen apparatus several hundred tons of cossettes directly from the presses may be dried per diem. This apparatus consists of two long drums in forged iron (I and II), about 43 feet in length and 4½ feet in diameter, each of which is composed of three sections, having iron rings at each of their extremities, and working on trolleys. Their rotatory movement corresponds to a velocity of five to six revolutions per minute. The pressed cossettes fall by *K* into the first drum, passing through the same very slowly, and the hot gases from the furnace move in the same direction. In the first drum the temperature of these gases is about 140° to 150° C. The motion of the cossettes is produced partly by the current of hot gases that carry them and also by a heating apparatus arranged as a spiral inside of the appliance. The early arrangement had a fire-grate, over which air passed, in front of each cylinder. At *E* they fall into an oblique spiral, *H*, which raises and compels them to fall into the second drum, where the temperature is about 230° F. The hot gases are drawn off by the so-called exhauster, *M*, and penetrate a dust chamber where the pulps that have been carried forward are deposited. The cossettes on entering the second drum contain 50 per cent. to 60 per cent. moisture. They give up their remaining moisture on entering the second drum, II, and fall upon the spiral, *F*, which conducts them to the elevator, by means of which they are carried to the loft or store-room. Two drums are sufficient for a factory slicing 150 tons of beets per diem. The motive power for all the drums, spirals, lifts, etc., is not more than 15 to 20 horse-power. The entire plant does not mean an expenditure of more than 55,000 marks to 60,000 marks [$13,500 to $15,000], including building, chimneys, etc.

Residuum having originally 85 to 90 per cent. water, retains only 8 to 12 per cent. when the operation is complete. Consumption of coal is about 180 to 220 lbs. per 100 lbs. of residuum dried. In Germany, the product finds a ready market at about $27 per ton. The actual cost of the method is $16.80 per ton of dried product obtained. The daily production being 18 tons, the daily cost of working is about $300. The shape of the cossettes has an important influence on the working of the machine.

Fig. 18.



Petry-Hecking Dryer.

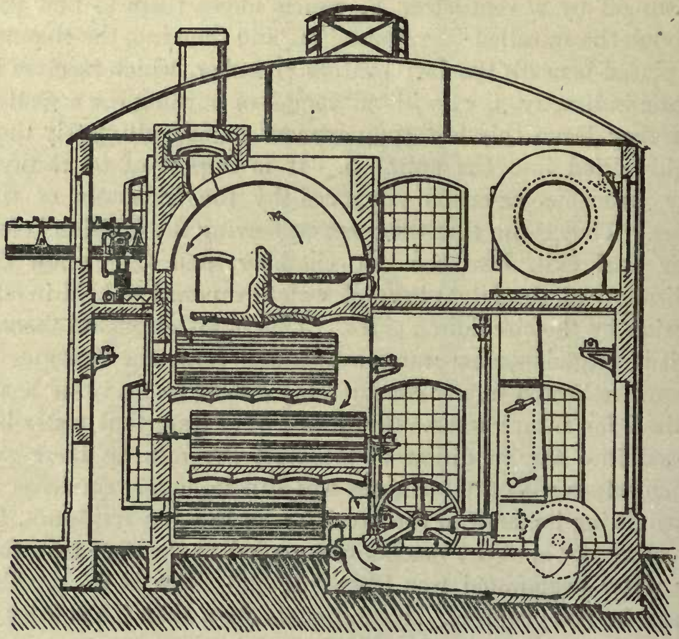
The Petry-Hecking dryer. The Petry & Hecking dryer consists of several successive chambers in the shape of a trough, in which the agitators revolve, forcing the cossettes to move forward and projecting them from one compartment to another through the openings that are arranged in the separating division. These passages are not in each case in the same position, and under these circumstances the gases and cossettes are forced to take a zig-zag motion in passing through the apparatus. In this dryer, as in the appliance already described, the gases move in the same direction as the cossettes, but they leave them before reaching the last compartment of the apparatus, from which they are drawn off by a ventilator, *V*, which forces them to first pass through the so-called "cyclones," *C*, and then into the channel, *K*, placed beneath the last heating chamber, which receives its caloric indirectly, *i. e.*, without danger of burning the cossettes. But they leave this last compartment to fall ultimately thoroughly dried into the spiral, *S*. It is important to rectify a very erroneous assertion advanced by the inventors of this dryer. They claim that the gases on leaving the division before their final exit, heat the last chamber, and thus allow the utilization of the latent heat of water evaporation held in suspension by the circulating gases. This is an erroneous theory; as it is impossible for water evaporated from the cossettes to become re-heated to any considerable extent so as to be again utilized for future work. From the very time that water has passed into the condition of steam it becomes an inert gas, which mixes with the hot gases and can no longer condense in transmitting its heat to the cossettes, unless the residuum, for one reason or another, has become cooled at the very time that the water evaporated was liberated, and there is no possible reason for such cooling. Experiments show that 2,539 kilos of coke are needed to dry 21,000 kilos of cossettes in twenty-four hours. One man can attend to an apparatus of 100 tons capacity per diem.

Buttner and Meyer dryer.

Notwithstanding the numerous efforts made to solve this problem, from an economical standpoint, the Buttner and Meyer dryer actually holds its own to-day against all comers, mainly from a practical point of view.

The Buttner & Meyer furnace is based upon two principles, one of which is that the hot gases from the center of combustion which will evaporate the water of the cossettes, should be at the highest possible temperature in order to work economically; the second is that the cossettes cannot move in an opposite direction to the gases, but, on the contrary, they should circulate with them until they leave the apparatus. The second principle is a natural outcome of the first, as it is evident that gases at the temperature at which they enter the apparatus (not less than 400° to 750° C.—at first it was argued if the temperature was above 500° C., the cossettes would be burned), would immediately ignite if they were circulating in an opposite direction. As to the moist cossettes that come in contact with these hot gases, their temperature can never attain 100° C. so long as they

FIG. 19.

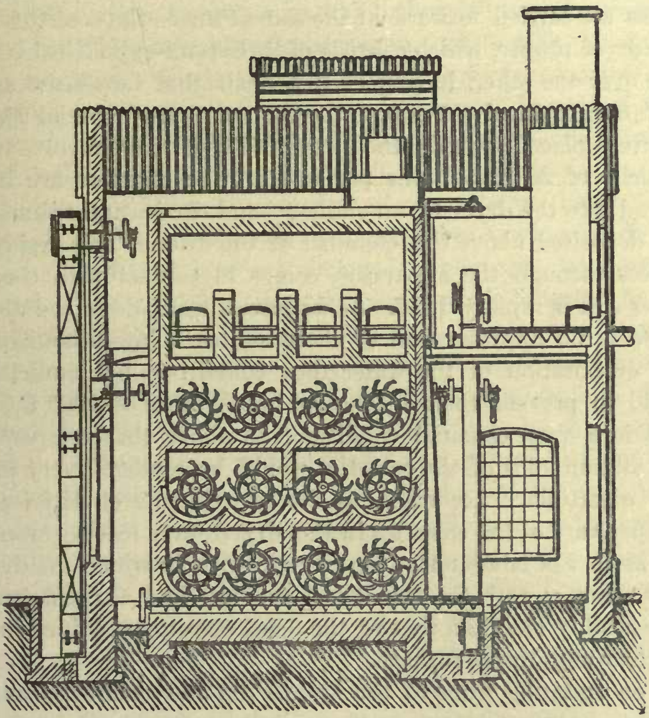


Side View of Buttner-Meyer Dryer.

retain moisture, as all the heat that the gases communicate to them serves in the transformation of this water into steam.

Upon general principles, the Buttner & Meyer dryer consists of a large brick frame-work, upon the upper part of which is a furnace, surrounded by a dome; in it the hydro-carbonated gases complete their combinations and are finally consumed, that is to say they are transformed into carbonic acid in consequence of their combination with air with which they come into contact. This frees these gases from the particles of soot that would contaminate the cossettes being dried, and which would consequently give them an unpleasant flavor. The bottom of the dome in question is divided in two by a small brick parti-

FIG. 20.



End View of Buttner & Meyer Dryer.

tion, on the one side of which are collected the ash, etc., that have been carried forward by the circulating gases. The suction of the air necessary is accomplished by the so-called exhauster, and may be regulated as the occasion may demand. When this is used for the burning of peat or other poor fuel, such products are first thrown upon a special grating, where they are carbonized and fall gradually from layer to layer until completely consumed. On the lower and upper portion of the dome the gases are carried forward at the same time as the cossettes into the dryer proper, which consists of three semi-cylindrical layers, one over the other, having each a shaft that forces the spiral agitators to revolve through the intervention of special conical gearing placed outside the dryer. These axes revolve at a velocity of 26 revolutions per minute, the cossettes are introduced into the dryer by an endless band carrier and spiral, and are deposited above the chamber of the drier. This residuum passes through the apparatus, comes in contact with the hot gases and is rapidly dried. As we have already described above, there is no apprehension of the cossettes being carbonized, as the evaporation of the water they contain is not sufficiently rapid to prevent their reaching a temperature of 100° C., and this is a very essential condition, as above that temperature the albuminoids of the cossettes would be rendered very much less digestible. According to the experiments of Kohler the temperature of the cossettes in this dryer never reaches even 90° C., as in his laboratory oven experiments, in which the drying was done at 90° C., the dried product had a coefficient of digestibility less than that of the dried cossettes obtained in the Buttner and Meyer furnace.

Temperature of cossettes being dried.

The agitating arms of the spirals are not combined as one might suppose, viz., so as to push the cossettes forward and force them out at the end of the apparatus. They are, on the contrary, arranged so as to compel them to circulate in the opposite direction from which they entered, but owing to a current of hot air they become dryer. The lighter portions are carried down to the second division, where the spiral arm arrangement raises them and brings them again in contact with the hot air until the moment that they are carried to the lower division of the apparatus. They are constantly brought in contact with the hot gases, and do not reach the bottom of the dryer until they have become sufficiently light to be carried forward by the circulating gases.

From what has just been said it becomes evident that the cossettes are raised continuously by the revolving agitators until a period when the hot gases will render them sufficiently light to be carried a little farther each time until they reach the exterior of the upper trough, from which they fall to the compartment directly beneath, always coming in contact with the circulating hot gases. They pass through the three divisions of the apparatus and finally fall into the cylindrical trough at the bottom, in which is a revolving spiral that forces the dried residuum to the exterior of the apparatus. As the circulating gases always carry a considerable amount of cossettes in suspension, this would mean an ultimate loss; so before leaving the dryer the gases are forced into a "cyclone" where the particles in suspension are deposited, and where they are collected to be subsequently added to the dried cossettes. A special chimney is connected with the dome of the dryer and serves for starting the fire. As soon as this cupola is sufficiently hot, and after the cossettes enter and the exhauster is working, the chimney is closed. As the occasion may demand, this chimney allows the escape of the gases of combustion at a time when the supply of fresh cossettes is less than the practical efficiency of the apparatus, due for example to a stoppage in the general working of the factory from which the cossettes are obtained. The cossettes would be burned if some means were not adopted to meet this emergency. Furthermore, it allows, upon occasion, an entrance into the furnace. It permits air to circulate in the dryer when necessary, by which means the gases may be cooled. The apparatus is regulated in such a way that the cossettes, on leaving the dryer, are sufficiently desiccated and the gases are sufficiently cool to attain their saturation point, without, however, being cooled enough to allow the water to condense. By approaching as nearly as possible this point of condensation, one realizes the economical working of the dryer.

According to Buttner and Meyer the final temperature in their dryer should be 110° C., which is sufficient to prevent the condensation of water without in any way destroying the ultimate value of the dried cossettes. By lengthening the time that the cossettes remain in the dryer one may obtain any degree of dryness that the occasion may call for. It would be possible to evaporate their water completely. However, this would be unnecessary, as the dry residuum would re-absorb 12 per cent. to 15 per cent. of moisture when coming in contact with the air. Buttner and Meyer do not go beyond a limit of 88 per cent. of dry matter, which corresponds with that of hay and other dry forage.

Complete drying unnecessary.

In order to regulate the temperature of the furnace and the exit of the gases, special appliances are arranged on the dryer permitting the air to enter in such quantities as circumstances may demand.

Regulating the dryer.

It is to be noticed that the amount of cossettes entering a furnace is an important factor as regards the final temperature of the gases. The smaller the volume of cossettes in the dryer the greater the tendency of the temperature to rise. This may be readily explained, as then a large portion of the caloric is not utilized for the evaporation of the water of the cossettes. The working of the dryer and the suction of the air should be regulated so as to correspond with the entrance of the cossettes into the apparatus. It is essential in this dryer that the suction of air should be regulated so as to correspond to the volume of cossettes being dried; excess would always mean a fall of temperature. The variations of temperature are very slight in the Buttner and Meyer furnace owing to the considerable mass of masonry of which the dryer consists, which within itself constitutes a sort of a heat regulator. The initial and final temperature of the gases are two facts that are most important to watch. The first can oscillate within the limit from 200° to 300°, and have, evidently, an enormous importance. An excessively low temperature would mean that too much air had been mixed with the hot gases, and there is no question but that it is far better to use directly the caloric of the fuel to evaporate water than to re-heat the air; the higher the initial temperature the greater will be the economical working of the dryer.

Fettback has analyzed the gases of this dryer in order to make sure that they are supersaturated with moisture. By observing the temperature shown on the moistened thermometer and that of the dry thermometer, and also the pressure indicated on a barometer, it becomes possible to ascertain the relative hygrostatic condition of these gases. Specially arranged diagrams showed the influence of the volume of the cossettes to be dried upon the final temperature of the gases and also their relative moisture.

When there are defects in the dryer they may be noticed by a fall of temperature of the gases and their comparative moisture. The regulating of the dryer may, to a certain extent, be done by ascertaining its practical working efficiency, allowing for the utilization of the caloric of the fuel.

Practical working of dryer.

We give herewith the formula proposed by Rydlewski for the calculation of the efficiency of a cossette dryer: We may suppose that Q is the weight of the fresh cossettes, and q the weight of the dried cossettes, t the temperature in degrees Centigrade of the moist cossettes, and p the weight of the coal, while c is the number of calories liberated by the combustion of one kilo. of coal.

$$\text{Caloric utilized } C = [Q - q][637 - t].$$
$$\text{Caloric furnished } C' = cp.$$
$$\text{Practical efficiency x per cent.} = \frac{100 \times C}{C'}.$$

Objectionable feature of dryers.

The application of this formula has given for the Buttner and Meyer dryer, as well as for the Petry and Hecking apparatus, an efficiency of 82.04 per cent. This formula enables one to ascertain within what limit it is possible to introduce moist cossettes into the dryer at a variable temperature, and to what extent temperature has an influence on the efficiency of the dryer. A rise of temperature of 30° to 35° C. means certainly an economy of 5 per cent. in fuel.

Some objections have been made to the Buttner and Meyer dryer, also to the Mackensen appliance, that there follows an important loss of dry substances carried forward by the hot gases. Some authorities have declared that this loss is 25 per cent. to 30 per cent., and even 40 per cent. This, without doubt, is a great exaggeration. Rydlewski has shown beyond cavil that when the dryer is conducted as it should be there is not a loss greater than 2.45 per cent. of dry substances, or 0.16 per cent. calculated upon the basis of the weight of the entire beet; this is especially true in the Buttner and Meyer dryer.

On the other hand, Kohler declares that in his investigations the losses of dry substances are 0.1 per cent. of the beets worked, and 1.7 per cent. of the total dry substances contained in the desiccated cossettes.

The Buttner and Meyer dryer has had many applications in Germany and in France, and our attention has been called to data obtained at a factory at Fisme (France). The plant has been worked with great satisfaction for several years, all temperatures being regulated automatically. Besides the regular plant there is also a steam engine. At first coke was the only combustible used, but at present any kind of fuel answers the purpose.

According to Brunehaut the analysis of fresh and dried pulp at Fisme was as follows:

FRESH COSSETTES.		DRIED COSSETTES.	
Water	88.40.	Water	10.36.
Dry substances	11.60.	Dry substances	89.64.

The efficiency of the dryer is about 900 lbs. dried cossettes per hour, and the consumption of fuel (coal) about 800 lbs.

If we admit 900 lbs. per hour, this represents about 21,600 lbs. per diem, and this amount contains 19,273 lbs. dry substances, corresponding in fresh pulp to 166,100 lbs. The amount of water evaporated is correspondingly

$$166,100 - 21,600 = 144,500 \text{ lbs.}$$

The consumption of coal is 19,200 lbs., consequently the fuel consumption per lb. of water evaporated is about 8 lbs. The cost of the dried cossettes including sinking fund for money invested and all other items was about $16.00 per ton, or 72 cts. per 100 lbs. This is certainly in excess of what it should be and may be due to fuel used.

Cost of plant. Opinions vary—some say to work 20,000 tons of beets the plant would cost at least $20,000.

COST OF PLANT IN RELATION TO ITS CAPACITY.

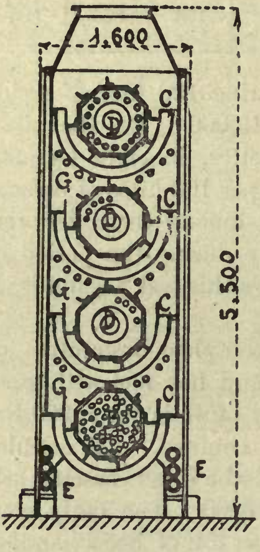
	A	B	C	D	E	F
Cost of installation....	$23,000	$28,000	$18,000	$15,000	$24,000	$32,000
Beets worked per diem.	300	300	200	150	350	300

For the United States a plant preparing 100 tons of residuum per diem would cost at least $45,000. On the other hand the average cost for drying cossettes, in eight German factories, it not more than 17.4 pfennig per 100 kilos of pressed cossettes, notwithstanding the fact that among these factories there was one that worked very poorly during the period of observation. In certain exceptional cases this cost has not been more than 14 pfennig.

Steam drying.

The steam drying method for the complete desiccation of cossettes is said to be a new departure, and has met with great success in Austria. The plant recently built is for a 900-ton factory, and cost about $80,000 in that country. All calculations made, it is estimated that even if the dried cossettes sell for $2 a ton the daily profits will be $200. The daily consumption of coal is about 100 pounds per ton of beets handled at the factory. In this steam method there is no danger of the residuum being burned by overheating, as is frequently the case by other modes of drying. It is claimed that nearly all the dry substances contained in the original beet are to be found in the final dried residuum (?), averaging 90 per cent. dry substances. The residuum cossettes, after being pressed in a Klusemann or Bergreen press are carried by a moving apron and emptied into a trough with revolving horizontal agitators, and heated with exhaust steam circulating in a jacket. The residuum is kept for a considerable time at a temperature of 40 to 45° C., and is subsequently run into special presses very much of the same design as Klusemann. To each press there is attached an apparatus not unlike a meat chopper in its general construction, and after this subdivision of the fibre, the residuum is carried by an endless screw to the dryers, each of which is about 5 feet wide, 18 feet long and 15 feet high. In its interior are four horizontal troughs, placed one over the other, each of which has a steam jacket. In each trough is a rotating, horizontal, tubular cluster, *G*, through which steam circulates, consequently the hashed cossettes are heated in the troughs and also heated during their rotating motion. The product being dried falls successively from one trough to another and circulates the entire length of each. When the dried cossettes finally leave the apparatus, another rotating device, in which there is no air, helps the emptying. The moist air from the oven is removed with a ventilator, the air passing through an arrester which retains all the solid particles in suspension. The entire motive power of the dryer is transmitted by gearing outside of the dryer. The dryer proper is metal; the exterior covering, however, is wood. The dried residuum leaves the dryer at 30° C. (86° F.). In different parts of the dryer the maximum temperature is 110° C. (230° F.). It is maintained that the following transformations take place: One hundred pounds of residuum pulp with 10 per cent. dry matter may be considered to have been obtained from 200 pounds of beets, giving 67 pounds cossettes, with 15 per cent. dry matter and only 11 pounds of dried product containing 90 per cent. of dry substances. German experience would appear to show that there was needed for the drying 80 pounds of coal per 100 pounds of dried cossettes, without allowance being made for the motive power. Calculated upon a basis of one ton of beets, this means that 120 pounds dried product demand 110 pounds coal. For the production of 10 tons of dried cossettes in 24 hours, there is needed a force of 50 H.P. It must not be forgotten that in the ques-

Fig. 21.



End View and Section of Steam Dryer.

tion of fuel consumption, the drying is done during the regular sugar campaign, and the steam used is simply the exhaust from the various pieces of apparatus of the factory. The daily capacity of the dryer may be increased by adding an oven to the series. It is claimed that with this apparatus, without any additional device, it is possible to use the dryers for mixing dried cossettes with residuum molasses. This device is so simple in its construction that a drawing was considered unnecessary to convey to the reader the general construction of the dryers.

Thiesen dryer.

The Thiesen dryer consists of a large vertical cylinder in which are placed alternately funnels attached to the sides, and a sort of plate or dish fixed to the axis of the cylinder. Special scrapers are placed on the axis of the dryer, which brush the funnels and force the substance being dried to fall upon the plates, etc. The substance to be dried enters at the top and leaves at the bottom of dryer. The Heckmann dryer consists of a large horizontal cylinder closed by a suitable cover with glasses for observation—the progress of the drying can thus be closely watched. In the interior is a series of platforms or shelves, having at their lower portion pipes for heating, which may be lengthened or shortened, as the occasion may demand. Piping on top of the cylinder makes a connection with the vacuum pump.

Composition and appearance of the dried residuum.

The dried cossettes consist of fragments, about one inch in length, and light green in color. To the touch they are rather resistant and readily break between the fingers, especially when they have been dried too much. Their average composition is as follows:

Average Composition of Dried Cossettes.

Substances.	Analysis of König.		Analysis of Pott.
Water	15.57 per cent.		10.0 per cent.
Nitrogenous substances	7.63 "		7.5 "
Fatty substances	1.09 "		1.0 "
Non-nitrogenous substances	49.65 "		58.4 "
Fibre	18.22 "		17.1 "
Ash	4.19 "	of which 0.398 oxid of potassium. 0.21 phosphoric acid.	6.0 "
Sand	3.65 "		

At one time it was admitted that if the percentage of nitrogen in fresh cossettes is one, that of the dried product is 8.16.

Cossettes compared with hay.

The composition of the dried residuum compares favorably with meadow hay.

COMPARATIVE ANALYSES OF DRIED COSSETTES AND HAY.

SUBSTANCES.	Dried cossettes.	Hay.
Water	11.00	14.3
Nitrogenous substances	7.87	9.7
Fatty substances	1.40	2.5
Fibre	20.00	26.3
Ash	7.14	6.2
Nitrogen-free extract	51.93	41.0

According to Pott the minimum and maximum variations in the composition of the product are as follows: Dried substances 84.2 to 94.7, nitrogenous substances 6.3 to 8.5, fatty substances 0.4 to 1.5, cellulose 13.5 to 20.7

The introduction and rapidly increasing popularity of desiccated cossettes may be explained by the important nutritive losses that cossettes undergo during siloing, which is evidently to their disadvantage.

Comparison between siloed and dried cossettes.

In certain cases sugar factories lose through neglect 20 per cent. of their cossettes [this in Europe is excessive]; this fact alone allows any one to approximate the advantages that will necessarily be derived from cossette drying. The saving thus effected, provided the product is utilized, constitutes an important margin towards the cost of the drying operation. Upon general principles dry forage of this kind has considerably increased in popularity of late owing to its healthy appearance, and also to its excessive digestibility. Maercker and Morgen declare that no product of fermentation is more digestible and more nourishing from any standpoint than are the fresh substances from which the dried residuum has been obtained. It is much to be regretted that no appliance has so far been devised that allows one to compute the digestibility of the non-nitrogenous extracted substances, as can be done with the nitrogenous elements by means of the Stutzer method.

It is declared that when non-nitrogenous extractible and digestible substances are mixed with the indigestible and exposed to the action of micro-organisms, a fermentation or putrefaction follows. The most soluble and most easily digested substances are the first to ferment and undergo putrefaction, and it is precisely in these compounds that the greatest losses occur. The soured residuums are less digestible than the fresh or than the dried cossettes, provided the desiccation has been effected at a sufficiently low temperature to prevent the albuminoids from becoming insoluble. As fermentation is a phenomenon that removes from the forage a certain amount of fuel, which means a reduction in its caloric power, it results in a smaller nutritive equivalent. Among the active elements of this fermentation may be mentioned acetic or butyric acid, which has, as determined by Weiske, a nutritive equivalent which is very small. They even occasion a decreased assimilation of nitrogen. However, it has been noticed that the lactic acid causes a slight increase in the amount of albuminoids deposited in the organism. In all cases these acids have a nutritive equivalent less than carbohydrates, from which they are derived, and it is easy to see that the cattle breeder loses very considerably from this point of view if one considers that acids form more than 20 per cent. of the dry substances of the siloed cossettes. Morgen, however, finds 17.98 per cent. of acids, and the maximum that he was ever able to discover was 28.98 per cent., calculated on a basis of lactic acid. It is important to add to this the fact that a portion of the albuminoids is transformed into amides, of which the nutritive equivalent is less, and can, according to Kühn, only be compared with carbohydrates in view of their economizing the albumen consumption in the organism. Finally, a portion of the albuminoids, according to Maercker and Meyer, is completely destroyed during fermentation; they are the most easily digested and they are the first, as previously stated, to disappear, as they are more actively influenced by the micro-organisms and consequently more readily fermented.

This explains the decrease in the digestibility of the albuminoids contained in siloed cossettes, which falls to 73 per cent., while the coefficient of digestibility is, for dried cossettes, 86.06 per cent. The importance, therefore, of the dry cossettes is manifest, not only for the sugar factories, where as we have before explained they reach enormous proportions, but also for the breeder.

Advantages of dried cossettes for feeding.

It is not only from this standpoint that there are advantages to be derived from this dried forage. If one examines the influence upon the organism of the large volume of water contained in the soured cossettes, the subject may be classified as follows: First, the cold water they contain has to be re-heated to the temperature of the body; second, the evaporation of water through the pores of the skin and lungs increases considerably, which demands a largely increased consumption of caloric; third, the amount of blood formed is increased, and with it there follows a considerable increase of wear and tear on the organism; and fourth, the consumption of albuminoids is increased, for the simple reason that an increased absorption of water is always followed by such burning.

Heat needed to evaporate water drunk.

Maercker and Morgen have demonstrated for the first of these clauses that if one divides equally between ten sheep a ration of 17.72 kilos. of cossettes per diem, and that if the temperature of these cossettes is 5° to 10° C., there would be required, to eliminate the water they contain, a temperature of the body of 37.5° C. This would demand 488 to 576 calories, which in other words means the heat liberated by 125 gr. to 150 gr. of starch, and they declare that, while this quantity may appear of very slight importance, when considered from the point of view of daily consumption, it becomes very significant after a long period. Furthermore, a greater absorption of water is always followed by increased excretion of the body in general, either through the skin or the lungs, through which a large quantity of water passes, and to transform it into a vapory condition demands a certain amount of caloric, which necessarily must be taken from the food consumed.

If one takes as a basis for his argument the experiments on respiration by Henneberg and Maercker, the conclusion would be that the increase of water to be evaporated is 40 per cent. of the additional water consumed. But Henneberg has recently demonstrated that this amount is excessive, and declares that of the water drunk not more than 7 to 17 per cent. is to be eliminated through perspiration, etc.

Vogel made a series of experiments with sheep, and concluded from one of these investigations that the average of evaporation was 30.78 per cent. of water absorbed. Another experiment gave 16.36 per cent., or an average for the two experiments of 23.57 per cent. But the ration under consideration contained only 0.6 kilo of starch. This quantity is lost as a forage as it has no equivalent as work. An increase in the quantity of blood without doubt results, but it remains to be proved whether the increase in question means additional work.

According to Volkmann $\frac{1}{300}$ only of the force developed by the heart is used, properly speaking, for the blood; the remainder is utilized to overcome the resistance of friction in the arterial and venous circulation. It remains to be demonstrated whether this resistance is increased in consequence of a greater quantity of blood put into circulation, or, on the contrary, is diminished, owing to the greater fluidity of the blood. Up to what point can these two contradictory elements be considered as compensating one for the other? Maercker appears to lean towards the theory of an increase in the necessary force at the time of the circulation under consideration. As for the consumption of albuminoids, it is, according to Mares, more and more pronounced when the previous ration was deficient in these elements. This would be due to a large consumption of water, for the simple reason that it destroys and decomposes the living substances of the protoplasm. If this absorption of water is of daily occurrence the weight of the animal fed may decline in a very marked degree. In order to overcome this decomposition and to reconstruct or build up the protoplasm, it becomes urgent to feed to animals elements richer in albumen than would otherwise have been necessary, as neither the fatty substances nor the carbohydrates can meet the demand.

Weisbeck has fattened cattle and has obtained the following results, which show the influence of the excessive water absorbed:

Ration of 40 kilos soured cossettes containing 35.85 kilos water and 4.15 kilos dry substances, increase of weight per diem 1.58 kilos.

Ration of 50 kilos soured cossettes containing 44.53 kilos water and 5.47 kilos dry substances, increase of weight per diem 1.23 kilos.

Henneberg has made similar experiments with milch cows, and has also come to the conclusion that there follows a decrease in the weight, with a slight increase, however, in the quantity of milk obtained, as shown herewith:

INFLUENCE OF WATER IN RATION ON MILK AND WEIGHT OF COWS.

Varying water content of ration.	Milk per diem.	Increase of weight per diem.
Ration containing 19.71 kilos water ..	13.36 kilos.	0.586 kilo.
Ration containing 28.50 kilos water ..	13.46 "	0.097 "
Ration containing 37.12 kilos water ..	14.15 "	*0.006 "

* Decrease.

Dried cossettes more hygienic than the siloed.

If it is true in agriculture that it is not desirable to throw away all that has an unpleasant smell, it is, on the other hand, desirable to be able to transform a forage that has a bad odor, such as soured cossettes, into an odorless forage, such as dried cossettes. Outside of the direct disagreeable features of siloed cossettes there follows an indirect unpleasantness. Some authors claim that the products of a dairy using soured cossettes have a slight smell and always retain it, and their conservation is also rendered more difficult. It does not necessarily follow that these substances are communicated directly to the said product by the passage through the organism, but the micro-organisms with which the forage is supercharged, float in the air of the stables, and consequently fall into the milk. Or, furthermore, they may reach the milk from the hands of those employed in doing the dairy work, who are, unfortunately, not over careful in the use of antiseptics. These micro-organisms give a slight disagreeable taste to butter and milk products. It is moreover well to add that soured cossettes may in certain cases develop disease, such as epizootic and catarrh of the stomach and intestines.

It is furthermore to be regretted that siloed cossettes are frequently handled with great carelessness. Maercker and Meyer mention one case where the cossettes remained in silos in contact with dead animals and became infected with disease. Under such conditions siloed cossettes naturally cannot be considered a desirable forage, as such products are not only detrimental to the health of the animals fed, but also to their descendants.

Dried cossettes more readily handled than the fresh or siloed.

Among the indirect advantages possessed by dried cossettes is the fact that the work of oxen is lessened in the fall of the year. The weight of dry cossettes is $\frac{1}{8}$ of that of pressed, fresh or soured cossettes. In most instances the beet wagons may return empty, and in this way one avoids the loss of time occasioned by the long period of waiting in the yards of the factories for the return loads of fresh cossettes. Again it may be pointed out that these long waits are hurtful to the general health of the animals. Thus the economy obtained by the use of dried cossettes in the matter of the transportation from the factories to the silos and then to the stable is considerable. Heine states that this cost is 10 pfennigs per 100 kilos for a distance of three kilometres. The carriage for longer distances by railroad is often greater. Under all circumstances there necessarily follows a considerably economy in the amount of wear and tear that the draft-animals are called upon to undergo.

Mineral substances in the dried cossettes.

It is to be noticed that the cossettes contain considerable mineral substances. This is one of the objections to cossette drying by means of direct fire. The ash carried forward by the circulating hot gases adheres to the cossettes that are yet moist. It would be possible to decrease this action by forcing the gases through metallic gauze with a very close mesh, which would retain the suspended cinders. If, for the purpose of drying, one uses coke on the grate, and this coke contains sulphur, the resulting product will necessarily have a bad odor when moistened. While this may not have any complicated or objectionable influence when considered from a hygienic standpoint, the cattle to which it is fed will frequently refuse it. The dried cossettes, furthermore, have the advantage over the soured product of facilitating the compounding of a ration, for the simple reason that its composition is almost constant, whereas soured cossettes leave much to be desired on this point.

Conservation of dried cossettes.

The dried cossettes have, as regards their keeping powers, a great advantage over the siloed product. They require, however, a covered building protecting them against rain, etc., for their preservation and storage. It is not necessary to bestow more care upon them than is given to any other dry forage. Helbrigel placed cossettes in a moist environment for three months, and the residuum did not absorb more than 15 per cent. of moisture, showing that it has little hygroscopic power.

Change during keeping.

Other experiments have been made by placing the dried cossettes in a very damp cellar for six months, when they became moist and mildewed. These experiments, however, were made under exceptional conditions, which are not found in practice.

Cossettes that are dried at a low temperature would, however, absorb a little more water, but when they are placed in a moist storehouse at a low temperature they will take up 20 per cent. water and remain in this condition for a long period of months. They will not mildew any more than does hay during its keeping. Under normal conditions it has been noticed that when giving this dried residuum the usual care the loss of dry substances, after months of keeping, is less than it would be with most of the standard fodders, and even less than it is with oil cake.

As is the case with all dry fodders, the cossettes increase in weight during the first year of their keeping, after which there follows a slight loss of dry substances. The increase is found mainly in the cellulose, the nitrogenous substances and the ash, while the gaseous extracts and fatty substances diminish. As a general thing the mass, after being kept some time, becomes possessed of a certain butyric odor, which is the outcome of the gradual oxidation of the carbohydrates and the fatty constituents, which fact in itself explains the decrease in their percentage. As for the albuminoids, they undergo no change as regards their quantity, but their quality slightly diminishes, as is the case with all other substances contained in fodders in general. A cubic metre of the dried residuum weighs 300 kilos. It occupies, consequently, one-half the volume of either the fresh or the siloed cossettes.

Digestibility of cossettes.

Morgen, in 1888, published a series of investigations on the digestibility of the nitrogenous substances contained in fresh, soured and dried cossettes, which demonstrated that the assimilability of their constituents was about the same for each form of cossette. From the data he then obtained he concluded that the albuminoids of siloed cossettes could not be considered less digestible than those of the fresh or dried residuum. They appeared, on the contrary, to be possessed of considerable advantages in this respect, which led to the conclusion that if there is a loss of albuminoids in a silo, the value of soured cossettes as a forage was not lessened; on the contrary, their digestibility had increased. These experiments led to the following results:

RELATIVE DIGESTIBILITY OF FRESH, DRIED AND SILOED COSSETTES.

Various fodders.	Digestible raw protein.	Digestible albuminoids.
	Per cent.	Per cent.
Pressed fresh cossettes............	76.3	76.3
Dried cossettes	79.7	79.7
Siloed or sour cossettes	83.2	81.7

The difference in the analysis, between the soured cossettes and the other two products, appears to be caused by the excess of nitrogenous substances that are not necessarily albuminoids and which are indicated as raw protein. Morgen declares that these data are entirely too favorable to the soured cossettes. He finds that these results are in contradiction of what has as yet been obtained in practice and asserts that this is due mainly to the fact that the dried, fresh and soured cossettes, when examined had not the same common source, that is they were not from the same beets.

Morgen undertook another series of investigations with Maercker, taking this point in consideration, and they obtained, for an average of their experiments, a coefficient of digestibility of 86.75 for the dried cossettes, and 73.02 per cent. for the soured cossettes, which means a difference of 13.73 per cent. in favor of the dried residuum.

The keeping of cossettes reduces in a very perceptible degree their nutritive value. The dry substance of dried cossettes contains 9.02 of protein, or $\frac{9.02 \times 86.75}{100} = 7.93$ per cent. of digestible protein, while the siloed cossettes with their 10.61 per cent. of protein in the dry substance contain only $\frac{10.61 \times 73.02}{100} =$ 7.75 per cent. of protein that may be assimilated.

The coefficient of digestibility of protein of different forages was established by the agronomic station at Halle sur Saale, Germany. The conclusion to be drawn from this data is that dried cossettes far excel all forages when considered from a nutritive standpoint. In Germany this forage is estimated as having considerable money value owing to this nutritive quality, and also for the reason that cattle fed upon it appear to keep in a very healthy condition. The only element that can reduce the digestibility of the product is heat.

Morgen determined an average from three experiments upon the digestibility of nitrogen, and showed that it ran from 76.3 per cent. to 79.1 per cent. with fresh cossettes dried at a temperature of from 75 to 85° C. Another experiment, made with dried cossettes at 75 to 85° C., in which the coefficient of assimilation of nitrogen was 78.8, gave on heating to 125° to 130° C., a lowering of the digestibility to 65.8 per cent., or a decrease of 13 per cent. These figures show the importance of carefully watching the dryer, so as to prevent the temperature of the product from rising above 100° C.

Precautions in feeding.

Dry cossettes constitute a nutrient for animals of which they are very fond, and it is important to take certain precautionary measures to prevent cattle from eating it to excess. Sheep, for example, will eat it with great avidity if they are allowed to do so. They eat entirely too much of this dried product and then take water into the stomach, which is followed by an abnormal swelling. Under these circumstances it stands to reason that serious complications will follow. It frequently happens that sheep are strangled by swallowing this desiccated residuum too rapidly. It is, however, easy to avoid such accidents by merely mixing the cossettes with about 40 per cent. of water and allowing the product to swell. Ritter mixes only 16 per cent. water. Some recommend that the cossettes be well ground into a powder. By such precautions the product is swallowed with ease and eaten with relish. However, when first fed the dried product may be refused, which is probably caused by the curious texture of the forage that may be unpleasant to the eye, or for other reasons; however, such cases are the exception. After several days the animals become accustomed to the cossettes and will eat all placed at their disposal. Up to the present time not a single case has been recorded where an animal has continuously declined to eat this dried residuum.

Pfeiffer and Lehmann declare that when dried cossettes are fed to an excess, they bring about troubles in the intestinal canal, which, as we may readily suppose, diminishes very materially the coefficiency of digestibility of the fatty substances; and notwithstanding the fact that animals being fed will increase in weight, there is always danger of considerable loss of nutritive substances in the droppings during over-feeding.

It must be understood that it is not imperative to mix the cossettes with water, as sheep will eat them in a dry state; however, the mixing of water as previously explained is an advantage. It allows the cossettes to be more readily combined with other forages, for, as previously pointed out, the dried cossettes alone should not make up the ration. Notwithstanding its comparatively small volume the product soon satisfies the animals' hunger, due possibly to the swelling of the beet cells in the presence of the fluids of the stomach, such as gastric juices, etc. The quantity of this feed to be given to animals differs with the object in view. According to Mercker and Morgen the amounts may be as follows:

Quantity of Dried Cossettes to be Fed.

Cattle fed.	Normal rations.	Maximum rations.
	Per diem.	Per diem.
Milch cows	3 kilos.	4.5 kilos.
Steers	5 "	7.5 "
Working oxen	4 "	6.0 "
Sheep	0.33 "	1.0 "
Young cattle	1 "	2.0 "

Experiments in feeding different kinds of cossettes.

In some comparative experiments coming under our notice there were two lots of three bulls each, fed upon the product for thirty days, also two lots of sheep of twenty-two head each were submitted to the same fattening process for forty-six days. The results obtained with either fresh or dried cossettes were almost identical. Certain indications, however, would lead one to suppose that if the experiments had extended over a longer period, the results would have been even more encouraging, and possibly in favor of the dried product. Apparently one part of dried pulp is equal to eight of fresh pulp. Animals fed with both pulps gave milk of the following composition:

Composition of Milk from Cows Fed on Fresh or Dried Cossettes.

Composition of milk.	Fresh cossettes.	Dried cossettes.
Density	1.04	1.045
Butter fat	3.90	6.35
Milk sugar	3.08	3.00
Casein	7.97	11.42
Mineral substances	1.10	1.14
Total solids	16.05	21.61
Water	83.95	78.89

In other experiments, with 24 cows yielding between 14 and 20 quarts per head and per diem, the feeding lasted 80 days, divided into four periods of 20 days. During the entire time of feeding, all the cows had regular rations of 12 lbs. hay, 2.2 flax flour, 2.2 cotton flour, 4.4 lbs. arachide flour, 6.6 lbs. barley bran, and 22 lbs. oat straw, to which was added during the first and fourth periods, 110 lbs. forage beets, during the second period, 17.6 lbs. dried cossettes, and 1.67 lbs. siloed pulps during the third period.

The nutritive value of these rations may be better understood by examining the table herewith:

COMPARATIVE NUTRITIVE VALUES OF RATIONS VARIED BY ADDITION OF DIFFERENT BEET PRODUCTS.

Varied periods of feeding.[1]	Nitrogenous substances.	Carbohydrates.	Fatty substances.
1st and 4th periods.	3.15 kilos.	13.05 kilos.	0.49 kilos.
2nd period	3.11 "	13.09 "	0.51 "
3rd period	3.14 "	13.07 "	0.49 "

[1] See paragraph above for rations fed.

From which we may conclude that apparently there was very little difference in the theoretical nutritive value of the combination used in each case. The practical results obtained showed that the quantity and composition of milk obtained was as follows:

COMPARATIVE ANALYSES OF MILK GIVEN WHEN DIFFERENT BEET PRODUCTS WERE FED.

Varied periods of feeding.[1]	Weight of milk.	Composition of milk.	
		Dry substances.	Fatty substances.
1st period	30.25 lbs.	12.87	3.51
2nd period.........	31.00 "	12.88	3.60
3rd period..........	31.60 "	12.72	3.45
4th period..........	26.64 "	12.72	3.45

[1] See paragraph above for rations fed.

The forage beets produced inferior results to the dried or siloed cossette residuums. All facts considered, in these special experiments everything appeared favorable to the siloed product rather than the dried.

According to Vibrans it is impossible to feed as much of the dried cossette product as animals can consume. Experience seems to show that it is unnecessary to feed hay to animals in conjunction with dried cossettes.

Maercker and Morgen have published considerable data on their investigation relative to the feeding of this product to cattle and the profits that resulted. The first experiments were those made at Schlanstedt with five groups of oxen. The ration fed was as follows:

THREE EXPERIMENTAL RATIONS FED TO OXEN (MAERCKER & MORGEN).

Components of Ration.	Series I.	Series II.	Series III.
Cossettes	20 kilos.[1]	5.18 kilos.[2]	6.93 kilos.[2]
Distillers' slops	30 “	30 “	30 “
Hay	2.5 “	2.5 “	——
Cereal balls	3.08 “	2.84 “	2.83 “
Rice flour	2.27 “	0.54 “	0.54 “
Lupine	1.35 “	1.47 “	1.88 “
Total	59.20 kilos.	42.53 kilos.	42.18 kilos:
Dry substances	12.33 kilos.	12.73 kilos.	12.32 kilos.
Assimilated nitrogenous substances (Stutzer)	1.518 “	1.490 “	1.471 “
Assimilated non-nitrogenous substances	6.95 “	6.93 “	6.92 “

[1] Siloed.

[2] Dried.

The amount of rice flour was decreased in the second and third series and the hay ration was entirely done away with in the third series so as to give every possible advantage to the cossettes and determine within what limits they could take the place of this forage. The amount of lupine used was made to vary so as to keep the nitrogenous substance up to the desired standard. The results are shown in the table herewith:

RESULTS OF EXPERIMENTAL RATIONS (MAERCKER & MORGEN).

Items of Profit.	Series I.	Series II.	Series III.
Daily increase in weight....	1.195 kilos.	1.377 kilos.	1.438 kilos.
Money value of the increase.	118.5 pfennigs.	130.4 pfennigs.	134.0 pfennigs.
Money value of droppings considered as a fertilizer..	38.8 "	35.8 "	35.1 "
Total	157.3 pfennigs.	166.2 pfennigs.	169.1 pfennigs.
Cost of daily ration	129.6 "	123.8 "	118.9 "
Profit	27.7 pfennigs.	42.2 pfennigs.	50.2 pfennigs.

The advantage is, without doubt, in favor of dried cossettes. In other experiments made in Germany, six milch cows were fed during ten days with a ration consisting mainly of siloed cossettes, then ten days on a ration of dried cossettes, and finally ten days on soured cossettes. These experiments are of less practical value, as the animals fed were sick during the first and second periods of the investigation. Herewith are the results of the experiments:

EXPERIMENTAL RATIONS FED TO SIX COWS.

Components of ration.	1st period.	3rd period.	Average of 1st and 3rd periods.	2nd period.
Cossettes	25 kilos.[1]	25 kilos.[3]	....	4.51 kilos.[2]
Distillers' slops	30 "	30 "	....	30.0 "
Hay	2.5 "	2 5 "	....	2.5 "
Cereal balls	2.0 "	2.0 "	....	2.0 "
Palm flour	1.0 "	1.0 "	....	1.0 "
Cotton seed flour....	1.29 "	1.28 "	....	1.58 "
Wheat bran	2.52 "	2.95 "	....	1.25 "
Total	67.31 kilos.	67.73 kilos.	67.52 kilos.	45.84 kilos.

[1] Siloed. [2] Dried. [3] Soured.

EXPERIMENTAL RATIONS FED TO SIX COWS—*Continued.*

Components of ration.	1st period.	3rd period.	Average of 1st and 3rd periods.	2d period.
Containing:				
Dry substances......	15.65 "	16.28 "	15.97 "	15.84 "
Digestible nitrogenous substances	1.75 "	1.86 "	1.81 "	1.80 "
Digestible non-nitrogenous substances.	8.41 "	8.61 "	8.51 "	8.72 "
Production of milk per head and diem.	17.03 "	17.97 "	17.50 "	17.84 "
Fatty substances	0.564 "	0.558 "	0.561 "	0.547 "
Increase in weight per head and diem....	0.068 "	0.104 "	0.086 "	1.320 "

Items of profit.	Average of 1st and 3rd periods.	2nd period.
Value of milk obtained............	175.0 pfennigs.	178.4 pfennigs.
Value of dropping considered as manure	38.0 "	33.9 "
Total	213.0 pfennigs.	212.3 pfennigs.
Cost of ration....................	162.5 "	155.7 "
Profits	50.5 pfennigs.	56.6 pfennigs.

The profits appear to be very much smaller than they should be, but it is important not to overlook the increase in weight of the animals fed. This increase, besides its intrinsic value, shows beyond cavil the healthy condition of the animals during the entire period of feeding, and this item is of an importance that cannot be estimated by figures.

All facts considered, there can be no doubt that the dried residuum has a most favorable action on milch cows, which has also been demonstrated in the experiments of Kellner and Andrä, who substituted 27.5 kilos of forage beets for 4.4 kilos of dried cossettes, which resulted in an increased milk production of 0.9 kilos per diem.

Another interesting experiment we may mention is that made at Hadmersleben, Germany, with two series of sheep fed for 101 days with the following rations, for ten animals per diem:

EXPERIMENTAL RATIONS FED TO TEN SHEEP (HADMERSLEBEN, GERMANY).

Components of ration.	1st series.	2nd series.
Cossettes	29.4 kilos.[1]	5.45 kilos.[2]
Distillers' slops	19.60 "	19.60 "
Pea straw	2.38 "	2.22 "
Cereal balls	3.00 "	3.00 "
Lupine	1.47 "	1.47 "
Poppy oil cake	0.88 "	1.14 "
Rice flour	1.79 "	0.98 "
Water directly consumed	1.74 "	9.12 "
Total	60.66 kilos.	42.98 kilos.
Contents of ration:		
Dry substances	13.91 "	13.95 "
Digestible nitrogenous substances	1.63 "	1.67 "
Digestible non-nitrogenous substances	7.26 "	7.61 "
Total water consumed	46.75 "	29.03 "

[1] Siloed. [2] Dried.

Items of profit.	1st series.	2nd series.
Money value of increased weight for ten animals fed	90.2 pfennigs.	107.2 pfennigs.
Money value of the wool	18.5 "	21.3 "
Money value of droppings considered as fertilizer	41.2 "	40.4 "
Total	149.9 pfennigs.	168.9 pfennigs.
Cost of ration	120.3 "	118.9 "
	29.6 pfennigs.	50.0 pfennigs.

The last series of tables herewith shows the economy and the profits of this system of feeding. Notwithstanding the heavy percentage of water contained in the soured cossettes, sheep, in order to quench their thirst, were obliged to drink water placed at their disposal, which in all cases was *ad libitum*. They consumed an additional 1.8 kilo. per diem and per capita, which in other words means 61 per cent. more than the animals fed with dry cossettes. Under these circumstances it is evident that this enormous quantity of water must have an important influence on the digestibility of the albuminoids of the animals being fed, influencing to a considerable extent the deposit of fat and production of muscular tissues, which will consequently be decreased in considerable proportions.

The experiments of Maercker and Morgen demonstrate that notwithstanding the low price at which dried cossettes may be produced, there follows an important increase in weight as compared with that realized with other feeding stuffs. In these discussions the enormous comparative value of the resulting manure from the animals fed with dry cossettes is generally overlooked, and shows to what extent these substances have been digested by the animals under observation. The average of the experiments of Maercker and Morgen with sheep has shown that there is an increased profit of 3.76 marks per 100 kilos of dried cossettes; with oxen, 3.06 marks; with milch cows, 2.18 marks.

Maercker and Morgen show that the average profit from the use of dried cossettes is 21 pfennigs for large cattle fed, per individual and per diem. It has a specially advantageous effect on working cattle, as they have in their intestinal tubes and stomachs a moderate amount only of nutritive substances, and experiments and observations have shown that the work they are able to accomplish is greater and their general health is better than are attained by animals fed with siloed and fresh cossettes resulting in full stomachs.

Potato feeds, such as are used in Germany, for swine, may advantageously be put aside in favor of dried cossettes. Under all circumstances it is found desirable to submit the fodder to a preliminary heating with hot water.

Beneficial effects.

Horses have excellent health when fed with this residuum, and upon general principles all animals without distinction, as long experience has shown, derive great benefit from this dried cossette feeding. Many of the complications that have been noticed in feeding with forages in general have disappeared when this residuum has been used; for example a paralysis of a special kind in sheep. The milk of sheep appears to be better, and the lambs are in a more healthy condition than when fed with other forages. There is nothing surprising in this, for the simple reason that the milk is less subject to alteration even in the udder than when siloed cossettes are fed.

Actual economy.

When one substitutes dried cossettes for intensive fodders there follows a much greater profit, as is also shown by the experiments of Maercker and Morgen. In Germany, 100 kilos of oats cost 17.8 marks and contain 8 per cent. of digestible nitrogenous substances and 53.3 per cent. of digestible non-nitrogenous elements. These may be replaced by 88.4 kilos of dried cossettes and 7.6 kilos of cotton seed flour, costing 5.68 marks. The profit is consequently 12.11 marks, or 68 per cent. Maercker and Morgen show that in numerous rations, where this intensive forage is used, it may be entirely replaced by the dried cossettes, to which other forages are added to make up the lacking elements.

RATIONS FOR LIVE STOCK.

Composition of ration.	Milch cows.		Steers.		Working oxen.		Sheep.		
	Ration per head and diem.		Ration per head and diem.		Ration per head and diem.		Ration for ten sheep of a total weight of 500 kilos.		
	Moderate.	Heavy.	Moderate.	Heavy.	Moderate.	Heavy.	Moderate.	Heavy.	Moderate.
	Kilos.	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*
Digestible nitrogenous substances.........	1.25	1.75	1.50	1.75	1.00	1.50	1.50	1.75	1.50
Digestible non-nitrogenous substances..	6.25	7.00	7.50	8.00	6.25	7.50	7.50	8 00	7.50
Hay	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Straw.................	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Dry cossettes	3.00	3.00	5.00	5.00	4.00	4.00	3.33	7.50	3.33
Palm flour............	—	1.00	—	—	—	—	—	—	—
Pea straw............	—	—	—	—	—	—	—	2.50	2.50
Potato distillery wash.	—	—	—	—	—	—	—	—	20.00
Wheat bran	3.43	3.14	3.33	3.97	2.79	4.70	7.00	1.03	1.29
Cotton oil cake.......	1.14	2.03	1.50	1.94	0.56	1.28	—	—	—
Peanut oil cake	—	—	—	—	—	—	0.25	1.74	0.54
Poppy oil cake........	—	—	—	—	—	—	1.00	1.00	1.00

CHAPTER III.

Early Prejudice in the United States Against Feeding Cattle with Sugar Beets and Residuum Cossettes.

RESPECTING American experience in diffusion pulp utilization, we would say that the farmers were at first opposed to it; and the total product of the diffusion batteries of the Portland factory, for the first year's campaign, was thrown into the bay. In subsequent years a portion of it was sold; those who experimented with it give some valuable testimonials regarding its nourishing value. Messrs. George Blansee & Co., of Cumberland, for example, estimated that it was worth, as a fodder for cattle, at least $5 a ton. The difficulty with which that company had to contend may be judged from a letter a New England farmer writes to one of our weekly papers, as follows: "The Maine Beet Sugar Company expected the farmers to buy back the pulp at $2 per ton, but could not make them see it! The pulp of potatoes * at the starch factory is worthless, and is shoveled into the mill-race. Why should that of the beet be any better?" It is to be regretted that communications of this character should receive public attention through the press or otherwise, and the writer would have been only too glad not to call attention to them, but it seems best to explain or rectify such statements. In the first place, the shoveling of potato pulp into the mill-race is a wasteful practice, as this refuse has a decidedly practical value as a fodder. It is in Europe generally combined with other roots, and in no case is it thrown away. These are facts that the farmer quoted above has over-

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*In France this potato pulp has many industrial applications, the most important being the manufacture of poudrette for manuring purposes. It is also largely used in the manufacture of tobacco boxes; it is also mixed with coal, etc., for fuel. If, after boiling, it is applied to cotton or woolen goods, it will give them a rich brown hue.

looked, and in his ignorance and prejudice he advocates that a still more valuable pulp from the beet should meet the same fate as that from potatoes. If this pulp utilization was a new idea, the question might be open to discussion; but the practice has existed in France for the past seventy years, and far from the diffusion pulp being refused by the farmers—as perhaps the above quoted correspondence would convey—they are unwilling to grow beets unless a certain proportion of the weight is returned in pulp, for which they pay a reasonable price. If the Maine Beet Sugar Company was unfortunate enough to have this contention with farmers who are unable to see what is to their own interest, that is no reason why all American factories should have the same difficulty. In conclusion it should be said, that the refuse from a starch factory has no more relation to the secondary products of a beet-sugar factory than the primitive roots have to each other. If, at the first, the nourishing equivalents of the beet and the potato had been compared, all would have been in favor of the latter; but the various processes of starch manufacture have attained a greater degree of perfection than those of the product of the beet. The problem of starch manufacture is far easier, because the numerous saline difficulties are not presented. This becomes more apparent when the results obtained at numerous starch factories are considered; the refuse from those at Watertown, for example containing only 0.01 to 0.1 per cent. of the original starch found in the potato. At the Delaware factory the demand for the beet pulp was so great that the company was unable to supply even one-half of what might have been sold. The same may be said of the Franklin Company. The Alvarado factory at first was not so fortunate, but California farmers now commence to appreciate the value of this refuse, as is demonstrated by the dairying experiment of the current campaign.

Of the annoying prejudices against pulps and beets we may mention one coming under our notice in the Northern States, where it was asserted that the amount of milk a cow would give per day would be diminished, and the milk would have a taste that might or might not be objectionable. Another example: One of our friends at Bryn Mawr, near Philadelphia, was feeding an infant with the milk of a cow, and positively declined to give beets in any amount to the animal that supplied the elements of existence to his beloved child, contending that the result might be disastrous to the infant's constitution, and also asserting there could be no possible doubt that the milk was directly acted upon by the food the animal consumed. There was nothing new in all this, but there was error when bad qualities were attributed to the milk yielded by cows fed upon green roots. There is scarcely any limit to similar examples, the patience of the reader must not be overtaxed by relating them; it need only be said that they have little force of argument. Similar theories were upheld against the potato prior to its introduction to our markets. After Sir Walter Raleigh was successful in convincing the inhabitants of Great Britain of its importance, it became, and is at present, the principal article of subsistence in Ireland; and when that crop fails there, famine is the usual result. The same rule applies now to the beet, and we can positively assert that, if it were no longer grown in the northern parts of France, it would give rise to a serious panic in that country. The number of cattle and the resulting revenue from their sale would necessarily diminish for the want of a substitute for the usual food, and the farming population would be the sufferers. The prosperity usually so great in the districts named would revert to the condition existing before these valuable roots were grown.

In the foregoing an instance of American prejudice as it existed sixteen years ago was given, and a recent and very extraordinary conclusion arrived at in Minnesota is quoted. The following items taken from the local press show in a most characteristic manner the complete ignorance of certain officials about subjects they are called upon to discuss.

In the *Minneapolis Tribune* we read:

"It is quite likely that the health commissioner, in conjunction with the dairy and food department of the State, will take action against the dairymen who are feeding their milch cows refuse from the beet-sugar factory at St. Louis Park.

"The commissioner took steps in the matter several months ago, but allowed it to drop because his authority in the premises was questioned. Now, however, he is free to act as he pleases, because of an act passed by the last legislature, entitled, 'An Act to prevent fraud in the sale of dairy products,' etc., which act places beet-sugar pulp in the same category as distillery waste, etc., and prohibits its use as food for cows in any part of the State of Minnesota.

"Many authorities claim that beet pulp is a wholesome food for cattle, but the dairy and food department of Minnesota apparently does not, and some action, therefore, may be looked for."

The *Minneapolis Journal* says:

"The point has been generally overlooked, but the last legislature did single out sugar-beet refuse for discrimination and put it on the forbidden list. H. F. No. 499, entitled "An Act to prevent fraud in the sale of dairy products, etc.,' drawn by the dairy and food department and expressing its ideas as to the necessary laws for the preservation of the dairy industry and the public health, under chapter 5 distinctly places sugar-beet pulp in the same category as distillery waste, etc., and prohibits its use as food for cows in any part of the State. The only qualification is that it may be used if properly preserved in silos.

"So far as known none has been so preserved, and so far as it has been used it has come from the big pile lying alongside the sugar factory. Under the law the pulp in its present condition is not being properly preserved, and milkmen who use it are doing so at their peril. The commissioner or anybody else who is convinced that the public health is being endangered by its use can take steps to stop it if so inclined. * * *

"The head of the dairy department took some pains last winter to look into the matter. * * * I will admit that the smell from the decaying surface of the pulp piles was not appetizing. But there is no reason in the world why a few inches underneath it should not be as fully preserved as if kept in an air-tight silo. There will be more or less fermentation, probably the same as in the silo, but that fact in no way detracts from the wholesomeness of the stuff as a food for milch cows or any other stock. The decayed pulp on the surface is, of course, wholly unfit for use.

"The chemist of the Department of Animal Husbandry took practically the same view of the case. He was unaware of the fact that the law had declared against the use of beet pulp, and thought it was a mistake to do so on the ground that the facts did not warrant such a law.

"Nevertheless, with all the authorities seemingly against them, it is understood that the dairy and food department of the State is prepared to enforce the law as it stands on the statutes."

Numerous similar examples could be given of tops and leaves, etc., being declared worthless for cattle feeding, the milk and butter being said to have unpleasant taste and flavor.

It has been apparently overlooked that frequently these products had been poorly siloed and when fed were in a semi-decomposed condition.

A very recent example is given in Bulletin No. 74 of the Utah experiment station, the title of which is "Lead in sugar-beet pulp." We extract from its pages as follows: "Though the intrinsic feeding value of sugar-beet pulp is so well established, there come to the station frequent inquiries concerning the possible danger in the use of beet pulp as a stock feed. Complaints are sometimes made that cattle are sick and dying, and as the only unusual condition was the beet pulp that they were receiving, the blame was unjustly attributed to the use of that food. It was discovered that beet pulp had been shipped in cars that had been used for hauling lead ore, and that the particles of ore remaining in the imperfectly cleaned cars had become mixed with the pulp, were eaten by the stock and had resulted in numerous cases of lead poisoning. The beet pulp should be shipped only in wagons or cars that have been thoroughly cleansed. In Utah, the danger from contamination with lead and other ores that remain in railroad freight cars is very great." This difficulty could in a large measure be overcome by introducing a suitable dryer at the factory, as dried pulps in bags would not be contaminated by exterior influences. Argue as one may the fact remains that there exists great carelessness in the shipping, and as a result the general utilization of this valuable residuum will be very considerably retarded. Many farmers do not seek for the cause, but are content to observe facts, their argument evidently now being that beet pulp contains lead ores and should not be used for cattle feeding. The intelligent feeder will avail himself of the Utah experience and insist upon a hitherto unknown care in cleaning cars that are to be used for the transportation of the product from the factory to the farm.

Successful introduction of pulp feeding in the United States.

In California the question of feeding cossettes to cattle has become very important. Among the early experiments we may mention those near Moro Coso, where success is assured. After one year's keeping the siloed product was so hard that it could be cut with a knife. Cattle showed greater preference for it than for any other fodder. The silo pits used are planked on both sides and bottom, with drainage box beneath. When the pits are filled the upper surface is covered with straw. Arrangements are said to have been made to use the sand hills for siloing, and to feed the pulp this year.

Efforts made at sun-drying beet residuum did not prove a success. The experiments at Chino in beet feeding are not sufficiently far advanced to report any special results. It is interesting, however, to call attention to some efforts made at the Linwood dairy of feeding bran and alfalfa with fresh beet pulp.

Early experiments at Chino.

At a later period Mr. Gird took up the question on a very thorough basis. At one time he wrote that the steers fattened were brought from Arizona and fed on siloed pulp and hay, in the ratio of about 5 pounds of chopped hay to 60 or 70 pounds of siloed pulp. It is recommended not to use the beet pulp until it has been in silos for at least 60 days.

An interesting example may be given of the excellent effects to be expected from feeding beet pulp to cattle. During the campaign about 60 wandering cattle were brought to the ranch; they were thin and in very poor condition; "they are now," says Mr. Gird, "as fine as any cattle I ever saw."

At first, they were fed on raw pulp, and afterwards on the siloed pulp, when the fresh product was exhausted at the end of the campaign. "They did much better on the siloed material than on the fresh," continues Mr. Gird, "I find that pulp, either crude as it comes from the factory or after it is siloed, is the best sheep feed I have ever used. With a very small amount of whole straw or hay with the beet pulp, the sheep fatten surprisingly soon, and their meat is very fine. Six weeks are sufficient to make a sheep as fat as needful, and as profitable and agreeable to use as mutton can be, and the trouble of feeding them is but little. As to dairy cows, only 60 pounds of siloed pulp are fed per diem."

"Although in the fall of the year the cows are by no means fresh, still they are doing as well as they would in the spring season on the best of green grass; the butter is of a fine quality, naturally hard and not in the least oily, as is the case with butter from alfalfa-fed cows; in fact, the butter is of a superior quality to any I have made from other classes of feed,"

Mr. Gird further says: "I have about 1,000 cattle in the pens, and am feeding as above stated. They are doing finely and take to the feed in the course of about a week, when they seem to eat it with more relish than anything that can be placed before them. I think it important to chop the hay, and intimately mix it with the pulp. I am using cornstalks, and by mixing with the pulp in this manner they eat every particle, and nothing is wasted."

"My silo is 500 feet long, 60 wide and 10 deep; the pulp is delivered into it from cars run on a trestle and taken out on two racks laid on the bottom of the silo on each side of the trestle, which I find a very convenient plan. I have from 10,000 to 12,000 tons of pulp in the silo now in magnificent condition; the cossettes (after having been freed from most of the moisture by drains and other appliances) have about the consistence of old cheese."

In a speech before the Dairymen's Association of Southern California, Mr. Gird expressed himself as follows: "My experience has been, that the dairy cattle will produce about the the same amount of butter, and of even better quality, when fed upon beet pulp than upon the best grass of pasture land. Late in the winter of last year, when grass was exceedingly good, after having fed pulp up to the time when it gave out, my dairy foreman informed me that the amount of butter was reduced nearly one-third in the week after stopping the feeding of beet pulp." * * *

"On December 16, 1893, I put 20 steers in a corral by themselves, and fed them each about 70 pounds pulp per day, with about five or six pounds rough hay or straw. * * * They weighed the day they were put in the corral 40,465 lbs., and were fed on pulp for 48 days. On February 2, 1894, they were taken out and weighed, their total being 43,125 lbs., or a gain in 48 days of 2,660 lbs.; this was 133 lbs. each, which is very good. * * *

"I have a silo calculated to hold 18,000 or 20,000 tons of pulp, being merely an immense trench dug in the ground, 60 feet wide, 10 feet deep and about 500 feet long. * * * I add a very small amount of salt to the pulp while being siloed. * * * The ease with which this pulp can be siloed and kept, is the great point in its favor, as it not only practically siloes itself, but becomes better as it gets older." * * *

Experiments at Oxnard.

No better evidence could be given of the increasing demand for the residuum beet cossettes than the description given of the Oxnard stock yards as described in the *Courier*. They were built in 1900, and there are four, the two larger ones being on an average 275 feet long, 45 feet wide and 9 feet deep, and the two smaller ones 250 feet long, 35 feet wide and 9 feet deep. The sides are sloping and the pulp is filled in to a level with the surface of the ground. The two smaller ones were the only ones filled in 1900, and contained 224 cars of pulp with an average weight of 35 tons to the car, making the amount of pulp stored approximately 6000 tons; this means the weight when first put into the excavations—it shrinks about one-third by the time it is fed to stock. The yards are north of the silos, and are divided into four rows of large corrals, between which the cars run. There are twenty-three of these corrals, and ten mangers of pulp troughs in each one just inside the fence by the car track. Nine of them are filled with pulp and the last one with salt. At the side of each corral opposite the places where the pulp is fed, hay and straw are placed. The cars which contain 8 tons of pulp are drawn up the track between the corrals and the pulp is unloaded into the troughs with forks. In this way 100 lbs. pulp and 14 lbs. of straw from wagons on the other side are fed to each animal each day. The ratio in 1899 was 10½ lbs. of straw and 112 lbs. of pulp to each animal. The corrals are built on sandy coast-land, and are well drained.

Experiments at Watsonville, Cal.

At Watsonville several thousand cows are fed upon siloed cossettes, which is an important progress as compared with the first years of the factory's existence. The residuum costs about one dollar delivered as it is used, and this includes loading, hauling, etc.

A recent government report states: "There was a time when the Pacific Slope used to call upon the Mississippi Valley for her butter and upon the Eastern States and New England for her cheese, but since the introduction of the beet sugar industry California has rapidly forged to the front as a dairy State. A large part of this change has been brought about by the introduction of beet pulps as food for the dairy. One of the most interesting examples of this fact will be found at Watsonville, Cal. Dairies have sprung up in all directions in that vicinity. Milk trains are running to San Francisco, and the dairy interests in that vicinity are almost wholly the result of pulp feeding. * * * It happens that the creameries there preceded the sugar factories."

A herd of 200 milch cows kept near a beet-sugar factory about 40 miles south of San Francisco, is given a daily ration of 60 lbs. pulp, 5 lbs. of mixed ground grain and a little hay. The cows milked averaged almost two gallons each per day. The milk is shipped to a dealer in San Francisco, who pays 12½ cents per gallon for it the year through. The production is greatest from February to May. Butter made from milk of this herd for experimental export was found to have exceedingly good body, a satisfactory flavor and an apparently first class keeping. Near Watsonville 100 lbs. are fed to each animal.

It is said that beet tops from certain California beet fields sell for $3.50 to $4.00 per acre on the ground. Many farmers fed the tops alone. Experience seems to show that with the addition of bran the results obtained are more satisfactory. Only in some exceptional cases were there complaints respecting the flavor imparted to butter through top feeding. An example of this top feeding may be given of a dairyman who brought his entire herd of 90 grade Durham and Holstein cows to the farm when he had bought the privilege of using the tops. The owner stated that their milk yield doubled in a short time. The beet tops in some cases are fed several months in the year. The butter from top-fed cows may be packed in rolls and covered with brine and be kept for months.

Conclusions of the California experiment station.

A correspondent of the California experiment station expresses himself as follows: "It would be difficult to economically feed pulp away from the factory, as the transportation and handling are quite expensive. Factories sell pulp at from 10 to 25 cents per ton, the former price having been the custom when taken away from the factory, the latter when conveniences and facilities for feeding cattle have been furnished at or near the factory. I doubt any profitable use of pulp for beet feeding at over 25 cents per ton. At this price and the usual value of grain and hay or straw, it will cost from $9.00 to $12.00 per head to put the animal in a good marketable condition. * * * I believe that small farmers who do their own work can functionalize cattle and fatten them and sell at a profit." As for dairy cattle feeding, it is claimed that 20 to 25 lbs. per head daily is a sufficient amount of pulp for a dairy cow, and to it there should be added 25 to 30 lbs. of uncut hay and 5 pounds of middlings. Another dairyman of some importance does not hesitate to feed 80 lbs. per diem, combined with 6 to 7 lbs. of hay and 6 lbs. mixed "chop" feed. A well known authority declares that the climate of California is not the most suitable for feeding purposes, especially in winter. Another correspondent advances views that are of considerable interest: "When cattle are once started on pulp feed, particularly when they are to be fattened for beef, it is advisable to continue them at that until fully fat, and then slaughter them. If cattle have been fed on this feed for a season, it is highly advisable, if they have reached the desired stage, not to take them on green pasture, as this affects them seriously."

Messrs. Jaffa and Leroy Anderson, discussing the question of cossette feeding from a California point of view, say that cossettes when fed in connection with other dry feed not only serve to keep the digestion in a healthful condition, but add materially to the store of actual food substance. It may be that 25 to to 30 lbs. per day of pulp will induce as large a flow of milk as 80 lbs. per day when the rest of the feed is dry; the idea being that the lesser quantity gives the cow all the succulent food and change of diet which she really requires for the best production. When the pulp must be hauled a long distance and the cost of transportation is therefore great, it would undoubtedly be unwise to feed it in larger amounts than just to give the necessary succulence to the ration, and 25 lbs. is probably sufficient for this purpose. But when the dairy is situated adjacent to the sugar factory, as at Alvarado, it might pay to feed the pulp in much larger quantities.

In California the general feeding with residuum cossettes has on the whole been very satisfactory, and a very extended trial has been given. The allowance per diem is 80 to 100 lbs. per 1,000 lbs. live weight. In some cases 10 to 12 lbs. of lima bean straw combined with the residuum have given satisfactory results; in others, 10 to 15 lbs. uncut hay and 25 to 50 lbs. finely rolled barley. The fattening lasts about 90 to 100 days. In one case 8,000 head of beef cattle were fed for four months. It was found that the meat from pulp-fed cattle was very much better than the alfalfa. "The meat was of fine flavor, good color, marbleized, and killing very white as to fat." The opinions as to the value of the residuum per ton is very varied, some saying 50 cents while others place the price at one dollar.

The California experiment station says that "the value of tops for feeding purposes may be estimated at $1.58 while for fertilizing purposes they would be worth $1.65. It is declared that if tops are used as food and the manure is saved, about three-fourths of the fertilizing value of the original substance is still retained. While this is true theoretically, it is hardly ever so practically, particularly with reference to the nitrogen, the most costly of the fertilizing elements. In very few instances, unless the animals are pastured, is the urine saved to the soil, and this part of the excreta contains the major part of the nitrogen. The nitrogen in the manure is not by any means all available, at best not more than 50 per cent., and in most cases not even so much. On this basis the fertilizing value of the manure would be about 80 cents (three-fourths of the potash and phosphoric acid and one-fourth of the nitrogen). This added to the value as food, $1.58, increases the net value to $2.38 and the difference (73 cents) between this sum and the fertilizing value, is fully made up in the green manurial value of the vegetable matter in the tops." The California station does not recommend the tops for dairies that supply milk to be consumed as such on account of the bitter taste imparted to the milk. "Experiments in feeding sugar-beet cossettes were not numerous, but the herd fed during a period of ten weeks showed that when no beet pulp was used, the cows ate on an average about 20 lbs. of hay per head daily in addition to 8 lbs. of grain, while when eating beet pulp, the daily consumption of hay varied from 6 to 10 lbs. The beet pulp seemed to impart no foreign or disagreeable flavor to the milk. The milk was delivered daily to customers in Berkeley and no complaint was made. The effect of the pulp upon the flow of milk was on the whole beneficial. Most of the cows were decreasing in yield up to the time when we began to feed beet pulp, after which all increased in quantity, and continued to hold out well until the beet pulp was exhausted when there was a noticeable decrease." The official report of the notes upon dairying in California says pulp has a tendency to fatten and is given to beef cattle without any other food, but for milch cows its effect is found to be best when used with a little grain or hay. Without the latter it is supposed to produce a thin and watery milk. When pulp is fed in considerable quantity the animals do not care for water and may go for months without drink. A feeder who has been using this by-product for several years complains that when his cows have been fed for a long time on pulp their calves are likely to come weak and troubled with sores.

In Nebraska the subject of feeding beet pulps to cattle is being very generally agitated, and farmers who have given the matter a trial are pleased with the results obtained. The fact that very little cotton-seed meal, oil cake, etc., is used in rations for milch cows does not prove that these are not beneficial. Many other by-products may take their place when heavy feeding is desired. The siloed pulp analyzed by the Nebraska station had the following composition: Water 88.64; acidity 0.19; dry matter 11.36; ether extract .09; crude protein 1.24; crude fibre 2.94; nitrogen-free extract 6.69; ash 0.39.

Experience at Grand Island, Neb. At Grand Island, Neb., a stock feeder who has had considerable experience with residuum cossettes says that when the feeding commenced he fed for several days 20 to 25 lbs. of pulp with hay and grain or meal mixed with it. This was gradually increased to 40 to 50 lbs. He also tried 80 to 90 lbs. per head, but considers this a disadvantage in fattening cattle, as they eat less grain and meal. Pulp helps to digest the food and lessens the danger of overfeeding. After feeding from ninety to one hundred days, he advises going back gradually to 20 or 25 lbs. of pulp per day, increasing the grain food, etc., and finds it better to give ground feed with pulp rather than whole grain. The pulp-fed cattle will sell as readily as any other, as they dress and ship as well, even for export. Cattle will eat poor and damaged roughage, which they otherwise would not touch, if it is mixed with pulp.

Experience at Ames, Neb. The leading pioneer of residuum pulp feeding in Nebraska has been the Standard Cattle Co., at Ames, and extracts and comments giving in considerable detail their experience from the beginning are quoted. Several years since the following statement was made: "Beet pulp cannot be profitably used, as I think, except when fed to animals that are sheltered in a warm place." No experiments had been made; this was simply an assertion. Since that time Mr. Allen, of the company, has given the question a great deal of attention. He says:

"The average amount of ground feed that we have given cattle in out-door lots, in mid-winter, ranged from 25 to 28 lbs. per day; indoor fed cattle, 16 to 20 lbs. Last winter we shipped pulp-fed cattle that had been fed only ten pounds of grain; some that had been fed only six pounds through three-fourths of their feed."

As regards cattle fed on grain, it is assumed that the number is 3,000,000, and the cost of food of each animal is estimated at $19. This means $57,000,000. The saving for cattle feed alone would be $20,000,000 by beet-pulp feeding. The beet-tops and leaves are estimated to be worth $2 per acre for feeding purposes. By the proper utilization of these, combined with the residuum pulp from factories, there would follow a valuable saving over the average cost of to-day.

Prof. Nicholson at the time stated, that the Standard Cattle Co. at Ames, Nebraska, fed pulp in three rations: First, ten pounds of oil cake and corn meal to from seventy to ninety pounds of pulp; second, six pounds of oil cake and meal to one hundred pounds of pulp; third, twenty-three pounds of ensilage to seventy pounds of pulp.

Mr. Allen some time since addressed to a government official the following remarks on silos which would hardly be acceptable in Europe: "The surplus that accumulates beyond requirements is thrown from the cars near the factory into a large pile awaiting use after the campaign is over and the fresh supply from the factory is cut off. From our experience I judge it is not necessary to take pains to preserve the pulp. At some sugar factories more or less expensive silos have been made, one, for instance, at Ogden, Utah, and similar ones at Lehi. I have no doubt there is a saving of pulp by the use of these silos, but I should judge the interest on the cost of these silos and the additional labor required in getting the pulp out would exceed the value of the pulp lost."

The experiments of the Standard Cattle Co. continue to be a pronounced success. The resident of the company wrote to a trade journal two years since as follows: "The past winter we fed on pulp 30,000 sheep which were fed regularly—the figures herewith are averages and include all classes of sheep. The heaviest wethers sold averaged 135 lbs. and heaviest lambs 100 lbs. at market. Some of the sheep sold on the Omaha market killed out 52 per cent. of dressed mutton.

"We have not, even to the largest sheep, fed to exceed eleven pounds per head a day at any time and our maximum average feed was ten pounds a day. We are inclined to think that this is too large a feed of pulp for grown sheep, and that seven or eight pounds is rather more than should be fed to lambs.

"At first the effect of heavy pulp feed is not perceptible, but after a while it is extremely diuretic in its effects and, we thought, produced a malady from which a number of sheep died.

"We regard seven pounds of pulp per day to lambs and ten pounds to sheep a maximum beyond which it is not safe to go. The total pulp fed was 11,971 tons."

In a recent correspondence with Mr. Allen upon the subject, he says: "There is no extended information respecting feeding pulp to cattle, as this is the first winter in which we are using it in any volume, and the feeding season is not yet half through; therefore, the only figures I can show you are those of sheep feeding. It will take years before there is any valued recorded experience in pulp feeding. I send you figures regarding our cattle feeding in order that you may see what a variety of products are fed to cattle and where the pulp will come in. No doubt we are this winter making a valuable saving of food products by the use of pulp, but we cannot demonstrate it in figures. I send you also some of our tables which may aid you a little.

"We are this year feeding 4,000 cattle and 31,500 sheep, which are being fed on pulp with other products. And we have also been able to make very good use of the beet tops left in the fields, having grazed our cattle altogether through a period of more than 60 days on as many as 1500 acres of beet fields after harvesting, getting therefrom possibly as much as $10,000.00 in food.

"In this part of the country where corn has been the only food product understood and appreciated by farmers, pulp has been little appreciated, and probably some experiments of feeding in midwinter have not been successful. It is gaining ground, however, in public opinion. Where it can be fed without freezing, its value is no doubt great enough to be well worth considering in a sugar proposition. I have been very careful about what I have said about pulp, but we feel now that it has greater value than we have ever yet felt free to claim for it. I append hereto our superintendent's opinion as to the value of beet pulp.

"In feeding 300 steers in one yard, we fed from one and one half to two loads of cut fodder per day with all the pulp they would clean up. The fodder weighs about 3,000 lbs. to the load. This year we figure 30 per cent. corn in the fodder which would make from 6 to 8 lbs. of corn to the steer per day, besides all the pulp he could eat. We got some of the yards up to 60 lbs., but they eat from 40–50 lbs. to the head per day. So I believe the cattle, which are on from 8–10 lbs. of grain, a fill on beet tops once a day, and all the pulp they can eat, will make a better gain than on a full feed of grain alone. By the time our beet tops were used up we had the cattle, as you are aware, up to a fair grain ration of about 10 lbs., besides what was in the fodder. As soon as we stopped feeding pulp we were compelled to feed each yard of 300 cattle from 30 to 50 cwt. of cut fodder more than they had been getting, and still with this increase the cattle did not look nearly so well. I am of the opinion that cattle, say on a 15 lb. ration of grain and 40 lbs. of pulp, will make a better gain than cattle on a 25 lb. ration of grain without any pulp; the only trouble that exists is that cold weather stops feeding outside. If one could have cattle ready to feed as soon as the pulp could be obtained, say September 15th to December 15th, this would give three months of good weather, and with the proper care, if one wanted to crowd either cattle or sheep, they would be in pretty good shape for a grain finish by that time. I believe one gets better results, or at least is able to see the results better, on older cattle than on younger. There were a number of milch cows on the place being fed on pulp and straw, without any grain whatever, and they kept up a good flow of milk and also gained in flesh.

"I believe pulp fed with corn fodder, straw or other dry foods creates better digestion, and animals are consequently able to get more good out of each product. Making a rough estimate I should say that where a person has stock, beet tops are worth from $5.00 to $8.00 per acre. With grain the price it is this year, I would value pulp at $4.00 per ton."

The Ames factory can slice about 500 tons of beets per diem; there remains consequently over 200 tons residuum pulp. The fact is the factory was the outcome of cattle feeding, and one of the main objects in view was the securing of the requisite pulp for the stock yards, while the reverse was the case of the Oxnard Co.

In Michigan, when there were only ten factories, they offered their combined pulp production to the stock yards of Chicago, simply asking that it be hauled away. It seems almost laughable that they did not avail themselves of it at once, but preferred to make investigations and thus the opportunity was lost. Nearly 50,000 head of cattle could have been fattened under most favorable conditions.

Michigan experiment station.

The Michigan State College Experiment Station has given the question of sugar beet cossettes serious attention, and an outline of the conclusions relating to the same is of great interest. Since the establishment of the several beet sugar factories in the State, a new stock feed has been placed at the disposal of the farmers. There is an urgent claim that the farmers have the product delivered to them containing 20 per cent. dry matter; this by usual means of pressing is hardly to be expected. In Michigan alone, even with the thirteen existing beet sugar factories, the annual output of the residuum cossettes is not less than 300,000 tons. It is to be regretted that most of this valuable product is lost, being simply taken from the factories by a conveyor, dumped and left to decay. Under these circumstances, the hygienic condition of the environment is in danger, and the residents in many cases make justified complaints. The Michigan station undertook the experiment, in a practical way, of testing the "value of beet pulp as a succulent food when combined with dry feeds." The first experiments were conducted on the Grafton farm near Alma. The main object in view was to feed several hundred steers with as little outlay as possible, while in experiments made at Pearl, in western Michigan, the steers were to be fattened as rapidly as possible. On the farm at Alma, the "herd was divided into two lots, one containing thirty steers to receive pulp, and the other twenty steers to be fed the same basal ration but no pulp. Prior to the beginning of the experiment, all of the steers had received pulp. It was necessary, therefore, gradually to remove the pulp from the twenty steers that were to receive none during the experiment. A comparison of the amount of feed required to produce a hundred pounds of gain indicates that 3,885 lbs. of pulp was equal in feeding value to 881.3 lbs. of stover, 1,086 lbs. of hay and 186.6 lbs. of grain. . . . The gain with the pulp-fed steers up was 2,815 lbs. or 93.8 lbs. per steer, while without pulp the twenty steers gained 1,120 lbs. or 56 lbs. per steer. . . . To carry a steer through thirteen weeks of winter, simply keeping the animal thrifty and growing, without an attempt to make the gains made in the interval pay for the feeds, required per steer 5.024 lbs. of pulp with 775.7 lbs. of mixed hay, 356 lbs. of shredded stover and 224 lbs. of grain. Without the pulp, it required per animal 275 lbs. more hay and 364 lbs. more stover. Taking these figures as a basis, and remembering that each pulp-fed steer gained 67 lbs. more in weight in the thirteen weeks, it is possible to estimate the value of the pulp as a factor in a ration designed to carry steers through the winter cheaply, if that form of cattle feeding is ever desired. The director of the Michigan station, discussing these results, says : "It required per day and steer with the pulp-fed lot 55 lbs. of pulp, 8.5 lbs. mixed hay, 4 lbs. of shredded corn stover and 2.4 lbs. ground grain. On this ration the steers made an average daily gain of 1.42 lbs. The lot receiving no pulp had for a daily ration 11.5 lbs. of mixed hay, 8 lbs. of shredded corn stover and 2.4 lbs. of grain, and made a daily gain of 0.684 lbs. Comparing the amounts of food consumed by each pen, to produce a hundred pounds of gain, and computing from this data the value of a ton of pulp as an additional succulent fodder, the tests show that under the conditions existing, a ton of pulp, fed with the other factors of the ration took the place of 421.5 pounds of corn stover, 274 pounds of mixed hay and 68.8 lbs. of grain.

The experiments at the Pearl farm are of equal interest. In this case a herd of twenty steers were divided into two lots, to one of which was given a ration of mint hay, wheat bran, and corn meal, while to the other lot was given the same ration and beet pulp in addition. The pulp-fed steers made an average daily gain of 2.52 lbs., while the steers which had no pulp made a daily gain of 1.84 lbs. Consequently a ton of pulp took the place of 244 lbs. of mint hay, 32.6 lbs. of wheat bran, 296 lbs. of corn meal and 27.2 lbs. of oats. It is interesting to recall the experiments in feeding dairy cows in the winter of

1898–99. The pulp used was hauled on cars from Bay City to Lansing, and it neither froze nor fermented, but kept fresh until eaten. It one case cows for some unknown reason refused to eat the residuum.

Without going into the details of this experiment, it is important to note that with pulp there resulted 128.4 lbs. of butter fat, while without pulp the yield was 130 lbs., which was not in favor of the pulp-fed cows, and apparently no advantage was gained. As regards milk production, there was a decided advantage in favor of pulp, for in this case there were 7,258 lbs. milk, and without pulp 6,844 lbs., a difference of 415 lbs., which is considerable. The practical feeders of Michigan express their opinion favorably as regards the expected advantages to be derived from residuum cossette feeding. With fresh beets the results were favorable, but, as might have been expected, with the frozen product complications arose. It is interesting to note what one farmer from Kalamazoo says: "I commenced feeding on one half a bushel of pulp a day and increased gradually until my cows were eating one bushel a day, but at that point they seemed to get tired of it, and the effect on their bowels was bad." It remains to be seen whether the pulp or the other constituents of the ration were responsible!

Cossette drying. In Michigan the question of cossette feeding has now been considerably extended, and a special appliance has been introduced for drying the residuum. *Louisiana Planter and Sugar Manufacturer* gives a description of it, as follows: "The pulp after leaving the factory contains 90 per cent. moisture. From the conveyor it goes to a set of apple-graters, where it is cut into small pieces dropping into large vats, where sufficient water is added to enable the pumps to handle it. Then it is forced through filter presses. There will be two presses of 40 cells each. The plates will be of wood, octagon in shape, covered with perforated brass plates No. 00 gauge. Between the plates are steel rings 35 inches in diameter by 4 inches wide. The pulp enters the press in three different places, and is evenly distributed to each cell by a spiral screw going through the center; the pressure carried is from 60 to 100 lbs. per square inch. Leaving the pressure with 60 per cent.

moisture, it drops into a screw-conveyor, the low-product molasses with it, and contains about 25 per cent. of water just before entering the dryer. The dryer is a large drum, made similar to a sugar granulator, being 6 feet in diameter and 40 feet long. There will be two of them making 6 revolutions per minute. Inside the drum enters a hot-air conduit (cone-shaped) perforated with 600 4-inch holes. There is an inner shell, one-half inch from the outer, running the full length of the drum, having shelves similar to a sugar granulator. This inner one is to protect the outer from coming in contact with the vapors, and also to retain the heat. The heat is generated by a coal or coke furnace, and is drawn through the drum by a suction fan at the discharge end, the heat being very intense on entering, but leaving the drum at only 130°. After traveling 40 feet in 35 minutes the pulp leaves the dryer, containing from 7 to 11 per cent. moisture. After passing through a set of rollers, being ground as fine as bran, it is then sacked for foreign shipment and baled so that a ton will go in 72 cubic feet. A 40 H. P. engine will supply all the power needed, and the building has two floors 50 feet wide by 75 feet long. . . . The cost is . . . $16,000, and the expense is about one dollar per ton of dry pulp.''

The official reports appertaining to the success of this plant were not favorable, while at Alma, where the second plant has been introduced, they are much more encouraging.

New York.

New York may be considered one of the important dairying States of the East, as it there has an influence directly and indirectly upon the entire rural question. During a long period of years farmers have been feeding brewers' wastes, and realize that the milk and butter from cows thus fed have been benefited. No other product within the past few years met the requirements of cheap dairying production better than this. Hence there has been comparatively little trouble in inducing the farmer to handle the product from the existing beet-sugar factories. This has been a considerable financial assistance to the Binghamton factory, who were able to dispose of their residuum at an average price of about 75 cents per ton.

At one time New York farmers were somewhat alarmed at the prospect of an invasion of live stock to be sent from Montana, which was to utilize the residuum of the beet-sugar factories,

Utah. At Utah several thousand head of cattle are fattened almost at the door of the factory. They consume over 100 lbs. of the residuum per diem, to which are added about 15 lbs. hay.

From the early building of the Lehi factory provisions were made for the pulp utilization, with the view of extending the dairying interest of the State. Several thousand head of cattle are fed.

New Mexico. In New Mexico 5000 sheep were fed in pens not far from the Carlsbad factory. No complaints were offered to this system of feeding, and the results taken on the whole were most satisfactory. Besides this attempt at feeding, the dairying farmers of the locality availed themselves of the opportunity.

At Eddy there have been fattened over 1000 head of sheep, etc., and the experiment met with success. The fattening reached nearly ½ lb. per diem. The residuum pulp was combined with alfalfa.

Oregon. The Oregon Sugar Co., during the last campaign, was able to dispose of several thousand tons of the residuum, which was considered encouraging, and, after it has been fed to sheep, other sales may follow; 10,000 tons of pulp remained, and nearly all of it appears to have found a ready market at a price which varied, according to quantity, from thirty to sixty cents per ton.

Minnesota. At Minnesota the Saint Louis Park factory has been fortunate in being able to dispose of its pulp as fast as produced. The selling price of the residuum is only about 20 cents per ton.

Colorado. From Colorado we learn that the Lockhart Live Stock Co. has this year been feeding 4,000 head of cattle with 30,000 tons of beet pulp. During the campaign previous the farmers took very little interest in this question of pulp utilization. At present they are entitled to 20 per cent. of all the residuum and are availing themselves of the opportunity.

Iowa. The importance of feeding pulp and beets to cattle was well expressed in a speech made in Iowa by our Secretary of Agriculture: "The managers of the Agricultural College of Iowa, where the finest animals of the United States are found, and where the best beef, mutton and pork ever taken to Chicago are finished, find it necessary to have roots; and I have no hesitation in saying that the Iowa farmer can afford to grow roots for his animals, no matter how cheaply he can get other feeds. The Iowa farmer can afford to grow sugar beets for the pulp alone. We must keep an eye on the South American republics. The Argentine Confederation has learned to grow alfalfa, and is sending very fat grass-fed animals to the European markets."

PART FOURTH.

CHAPTER I.

Molasses for Feeding.

Early experiments in molasses feeding.

THE first one to suggest molasses as a fodder was Hermstadt, in 1811. A special forage was, as early as 1830, made up of chopped straw and 100 kilos of molasses, as a total daily ration for 80 head of cattle, 2000 sheep and 20 horses. Petibval, who is a thorough believer in the importance of this utilization, especially for horses, at that time declared that with molasses half a ration of oats was sufficient, and numerous other examples could be given of the same kind.

In Germany, the first efforts to be recorded in this direction were by Stockhardt, in 1850, and later by Henneberg and Stohman, who fed to cattle a mixture of molasses, oat-straw and hay. They limited the amount of molasses to be absorbed to 8 kilos per 1000 kilos live weight of the animal fed.

In 1860, Fromenn and Rhode did not obtain very satisfactory results with milch cows fed with flour, straw and molasses. Gohren, on the other hand, had most excellent returns later on.

At this same period (1860), the use of molasses became very general in France and Russia. In the last-mentioned country it was noticed that molasses, when combined with straw or chopped hay, overcame certain existing diseases. Excellent results were also obtained on these lines in Bohemia.

In England, the use of molasses for cattle was not general before 1870. With the exception of the investigations of Rimpau and Christiani nothing remarkable was noticed in favor of molasses feeding. On the contrary, the peasants looked upon this product with apprehension, as they feared diarrhœa. Furthermore, the cost of molasses increased owing to the fact that it had a certain use in for the separation methods in sugar factories after most of the sugar was extracted and it was, in a measure, rendered worthless for feeding purposes.

In 1885 the sugar crisis demanded that certain measures be taken to find some means of increasing the sugar consumption in continental Europe, and therefore molasses was proposed as a forage.

The cost of this residuum upon the market decreased, thus rendering its utilization feasible, and as a result numerous investigations were made and taken up by the community in general. As matters now stand, the combinations may be considered a staple commodity on the usual markets, so much so that in Germany, in 1895, of 220 beet-sugar factories replying to questions put to them by a well-known authority, 130 declared that they sold their molasses for feeding purposes in the proportion of 10 to 100 per cent. of their production. Twelve of these establishments got rid of all their molasses.

General use of molasses for feeding in Germany.

The amount of molasses used for feeding purposes in Germany represented 27.6 per cent. of the total production during the campaign of 1901, and this fact alone shows to what extent the subject has been taken up in that country, it being not only the agricultural community that has become interested, but also the army at large.

The advantages for horses are self-evident. Stift says it is much to be regretted that, in Austria, there still exists a certain prejudice against molasses combinations, mainly due to the bad management of the middle-man. The army of the country is the sufferer.

Increasing popularity of molasses feeding in Austro-Hungary.

In Austro-Hungary, during 1900 and 1901, 6 per cent. of the total molasses production was used as a forage. In this same country 127 of the sugar factories got rid of their molasses in this way. It was fed directly to cattle, or in a diluted form, mixed with chopped straw, cereal waste, concentrates, peat, etc. Certain factories manufacture this feeding stuff, made up of molasses and peat, dried cossettes, brewers' grains, palm-oil cake, etc.

In Bohemia, two establishments prepare this fodder and collect the raw material at the factory proper. As an industry it would have attained an even greater extension in that country had not the beet-sugar factories found it advantageous to use this residuum for various purposes themselves.

Possibilities of molasses feeding in France.

It is estimated that the yearly production of molasses in France is 320,000 tons; if one divides this by the number of days in the year this would give 876,712 kilos per diem. If we admit that each animal receives only one kilo, there would be sufficient to feed 876,712 heads; but this represents only a very small portion of the total number of animals of the country which without considering the swine is 9,466,000, showing that however large the molasses residuum from beet-sugar factories may be, it would have to be several times greater in order to meet the demand, if molasses feeding were generally adopted.

Never before did molasses render a greater service to France than during the recent dry spell. Farming produce that would have been considered worthless for feeding purposes, has, by the addition of molasses, been made most palatable. A great mistake has been made in taxing this residuum beyond a rational limit. As a result the government has derived certain advantages, that have been neutralized by the limited utilization of the product among the large and small dairying centers. A paradoxical fact relating to the fiscal molasses question is, that the manufacturer has every advantage in selling his residuum to distillers or for exporting purposes, rather than to the tillers of the soil, who, from an agricultural standpoint, have the first claim. This fact explains why there should be, at this late day, an effort to look after farming interests from a molasses-utilization standpoint. The recent proposed changes make the question still more complicated.

Molasses utilization one of the essentials for profitable sugar making.

A beet-sugar factory, to work on a profitable basis, must utilize its residuums. Pulps, molasses and filter scums are products having a money value, and if not sold for their money equivalent should at least find some market or utilization and not be allowed to go to waste, which is the case with the beet sugar factories in the United States. The total daily capacity of existing beet-sugar factories in this country is about 33,000 tons, and the resulting residuum molasses is about 1,000 tons or 2,000,000 lbs., sufficient to feed 250,000 head of cattle for the entire working companies.

Importance of molasses utilization in the United States.

For many years past the question, from a cane molasses point of view, has been discussed before the Sugar Planters' Association, an account of which may be found in *The Louisiana Planter*. Many used three-quarters of a barrel per day for eighty head of stock, the consumption averaging about 5 lbs. per head per diem. It is found that the quantity of hay and grain food needed is considerably diminished by this utilization.

In Texas the cane tops are sprinkled with molasses and then fed, stock appearing to prefer it to grain. Some planters fed molasses to their mules and horses, and found that they consumed on an average 12½ lbs. per diem.

The following additional facts respecting beet molasses are considered very important. Molasses from sugar cane contains glucose; beet molasses is free from this sugar, but retains a larger percentage of salts and other impurities; hence the problem of feeding this product from a beet-sugar factory is more complicated than when handling a cane residuum. In both cases, however, it is mainly the sugar that represents its nutritive value, and the importance of it for the development of work, etc., is now admitted by all who have examined the question.

Rivalry among manufactnrers of molasses forages.

Between the various modes of preparing the molasses fodder, there has come into existence considerable rivalry, the various inventors condemning their competitors, and in this way retarding the progress that would otherwise have been made in the general introduction of the product on farms. The fact, however, remains that cattle fed upon the product have their appetites stimulated and eat more straw and like products than they would otherwise. As soon as there was a possibility of making the molasses fodder very general, the selling price of the residuum went up, which necessarily meant a set-back as far as its general introduction was concerned.

Since 1850 many arguments have been advanced that molasses contains all the nutritive elements that are requisite for feeding cattle. One of the first experiments that may be mentioned was that of Krocker, who substituted in sheep feeding one-third of a pound of molasses for one pound of hay per head and per diem. The excellent results that were obtained have been followed by numerous experiments, which have been more and more convincing. In the meantime several failures have been recorded, but these were followed by successes.

The average composition of molasses is about as follows:

Composition of molasses.

Molasses upon general principles may be considered as a product containing sugar that cannot be crystallized by any known method. Its composition is only then, to a reasonable extent, variable, and is about as follows:

Water 20 per cent. Dry substances containing: Nitrogenous substances 10 per cent., sugar 50 per cent., non-nitrogenous 10 per cent., salts 10 per cent. Molasses contains from 1 to 1½ per cent. nitrogen, sometimes more.

According to Briem, molasses contains 8 per cent. of digestible protein. This proportion is apparently excessive, as molasses analyzed by Beyer contained 1.47 per cent. of nitrogen, of which 5.3 per cent. was protein, 29.3 per cent. of organic substances, such as betaine, glutamin and asparagin, and 48.3 per cent. of amide compounds. The remainder was not determined.

Kühn is responsible for the assertion that of 100 parts nitrogen, 22.7 to 75.7, or an average of 34.4 per cent., are amides.

Albumen not contained in molasses.

One of the interesting features of this residuum is that the albuminoids are entirely absent; but there are besides the amides, certain acid and nitrate combinations of these substances. As a general thing, however, the nitrogen is found as an organic combination.

Varied opinions respecting the value of amides.

From these discussions, a mistake is committed in asserting that the nitrogenous substances of molasses are only amides, which are said to have no nutritive value and which cannot consequently take the place of elements containing protein. Recent experiments have shown, as previously explained, that amides have nearly the same digestibility and nutritive power as carbohydrates. Previous investigations in this respect have shown that the theory that two-thirds of the nitrogen in molasses, which we considered as albumen, is erroneous.

Authorities, such as Kühn, Ramm and Momsen, assert that these nitric substances have a very doubtful nutritive value, certainly not greater than that of carbohydrates, as their use for flesh and milk production is infinitesimally small. They have neither the chemical composition nor the action upon the organism that is possessed by albumen. They are mainly thrown out in the urine.

Weiske and Schulze declare that they are without nutritive value and are simply acid amides; hence it is argued that no allowance should be made for them in the calculation of a ration.

Substances other than amides and their influence.

Along with the amides, molasses contains from 40 per cent. to 46 per cent. of sugar, besides which we may add 16 per cent. of non-nitrogenous substances, meaning those which are not precipitated by lime during defecation.

Molassic salts are mainly carbonate of potassium and sodium, and also chlorids. They contain also lime, sulphuric acid and a small percentage of phosphate.

A certain nutritive value must be placed upon the non-sugar of molasses, as it has the property of exciting digestion and facilitating certain biological phenomena, such as the production of fatty substances and increasing the percentage of dry matter in milk. This property, attributed to nitrogenous substances and the salts of molasses, cannot be obtained by the use of salt alone. It is mainly this inexplicable property that constitutes the real value of molasses; consequently, one cannot deny that the nitrogenous substances of molasses have a certain nutritive value and other special actions which in no way depreciate the market value of the residuum. Even if we may make no allowance for the nitrogenous substances of molasses, its nutritive value is always greater than its market valuation.

Beneficial effects of molasses feeding.

Notwithstanding the great variations that have been found in the composition of molasses, up to the present time no instances have been recorded of any toxic effects that have followed from molasses feeding; but it has very correctly been noticed that a certain diarrhœa is apt to follow, due to the organic salts it contains. This is the outcome of an excessive use of this residuum for feeding purposes, and it is to be noticed that an excess of any feed would have the same effect. Consequently the farmer has every advantage in keeping the molasses percentage of a ration within the limits of a standard, just as is done with every other substance entering into its composition.

The salts contained in molasses, far from being objectionable, are on the contrary rather an advantage.

Physiological action of sugar and hydrocarbons.

The special nourishing value of molasses must be attributed to the percentage of its extractive elements, which, when compared with its caloric power, is very high, and demands an almost insignificant physiological work; thus sugar has an important value, as compared with all other hydrocarbons—being soluble in water, it does not necessarily demand the action of the gastric juices or the expenditure of latent forces of the organism for its assimilation.

Experiments have shown that sugar added to forages is without doubt an excellent, healthy and economical substance, producing at the same time flesh and fat. It furnishes, furthermore, the requisite caloric for the animal, and materially assists in the production of mechanical energy. Sugar-molasses possesses greater activity than sugar alone. Many investigations show that animals fed with molasses and the same quantity of sugar have always given better results than when fed with molasses only.

One need only compare the enormous benefit that man derives from eating sugar to realize the possible fattening results to be expected from feeding this substance to cattle. Throwing aside the nitrogenous value of the molasses constituents in estimating the commercial money value of the residuum, and considering only the hydrocarbons it contains, one realizes that it in reality has a greater money value than has hitherto been admitted; and all facts taken into consideration, when compared with barley, rice, various brans of wheat, etc., it holds its own.

Of all the carbohydrates sugar may be considered the most valuable. Being soluble in water, it does not demand any special digestive action, which is within itself a saving for the vital energy of the organism. Furthermore, it is pointed out that sugar, being diffusible, soon passes, by osmosis, through the intestinal tubes, while other non-nitrogenous extractive elements, such as starch, pentosanes, etc., must undergo many modifications, lasting for a considerable time, before assimilation is possible.

The osmotic action of a sugar solution is very rapid, so much so that the new theories claim that its complete oxygenation is impossible. The blood not being able to supply the oxygen necessary for its transformation, there results a stored-up energy for subsequent tissue and fat formation.

The other carbohydrates, under the influence of the gastric juice and other active principles secreted by the stomach, intestinal canal, etc., are transformed into sugar only after an interval of time, under which circumstances it frequently happens that the sugar thus formed is entirely consumed by the combustion of the body, and but little remains for tissue formation. Killner advances the theory that there are always certain carbohydrates very difficult to digest, and they, with starch, help the formation of methane in the intestines. No such transformations occur with sugar, and its purpose consequently is almost entirely one of organic production. Several agronomists point out that this fact alone gives sugar an advantage over all other carbohydrates for fat formation, and hence its value for cattle-feeding, either as it is found in molasses or in other forms that the farmers have at their disposal.

Manner of feeding.

Experience shows that it is desirable to commence the feeding with molasses in small quantities, gradually increasing the amounts; we may admit about one-quarter of the ultimate ration as a beginning. Even under these circumstances certain physical organic difficulties at first occur; but there is no reason for alarm, as they subsequently disappear. Among the numerous precautionary measures to be taken in feeding molasses, mention may be made of avoiding the exceptional molasses which contains excessive saline elements. The residuum from sugar refineries or factories where the sugar is largely extracted demands special attention, and hence in certain cases it may be found desirable to have made an ash estimation of the molasses that is to be used for feeding purposes. While the nitrogen percentage of the dry matter of regular molasses is 2.16, this percentage falls to 0.69 in molasses from the strontia process.

Milch cow feeding with molasses.

In certain cases there has followed a slight decrease in weight upon feeding molasses to milch cows, but the fact that the flow of milk has been increased must not be overlooked. Without doubt the product has an important action upon the milk secreting glands, and this secreting influence results in an increased flow of milk, which continues for several days after the molasses ration has ceased to be fed. There then follows a gradual decrease, which in certain cases falls below the normal. Hoppe attributes this exciting influence to the amides, such as asparagin, contained in the molasses; Ramm, on the other hand, at one time declared that the stimulation must be attributed to the salts of the molasses, but he has of late changed his opinion.

The relative amount of fatty substances contained in the milk of molasses-fed cows decreases during the period that this special fodder is placed at their disposal, but its absolute quantity increases. Allowance is always made for the absence of fatty constituents of molasses, by giving to the animals larger amounts of fatty substances, such as oil cake.

The milch cows in Ramm's investigations at first refused a ration consisting of equal parts of molasses and palm oil meal, but the same animals ate this forage when, later, the amount of molasses was lessened. When one compares the results obtained by molasses and other constituents, there can be no doubt that the resulting milk contains a heavier percentage of fatty and dry substances with molasses than is realized with other feeding stuffs. The quantity of milk is also considerably increased.

Holbrung and Kaiser fed to milch cows one kilo of molasses in one experiment, and 2 kilos per diem in another. This was either diluted in water, or represented a substitute for 2 kilos of bran. With the exception of one special case, the milk secretion was notably increased.

Molasses is apparently favorable to the production of milk, not only on account of the nutritive elements it contains, but also owing to the exciting action, due probably to the amide constituents, thereby causing an increase in the amount of milk per diem under certain conditions. With 2 to 4 per cent. molasses the fatty substances remain almost stationary; but as soon as 5 kilos per head are fed per diem there is to be noticed a decrease in the fatty substances, which frequently attain 0.5 per cent., hence the importance of adhering to a certain standard within reasonable limits. Without doubt, as before stated, the milk is of an exceptional quality.

As regards the evil effects that have resulted to milch cows receiving molasses in their daily rations during gestation, this is difficult to explain, and possibly the feeder was more at fault than the animal fed. Then again, the nature of the molasses may have been responsible, and among the authorities who argue from this basis, we may mention Hoppe, who says that the composition of molasses plays a most important role. He justly declares that molasses having become even slightly soured should never be used.

Among the interesting theories as regards the physiological influences of molasses, may be mentioned the excessive increase of the urine secretion of milch cows, which has a pernicious influence upon the heart and kidneys.

The protein percentage of milk does not appear to be influenced. This would show that molasses causes slight increase in protein, which would, in a measure, explain why the animals fed lose in weight. The relative amount of dry substances is slightly decreased, but to this very little importance need be attached, as is shown by the Fleischmann formula for milk analysis. The absorption of molasses increases the acidity of milk—especially the evening milk. Such milk will coagulate spontaneously after three or four days, while milk from cows that have not been fed with molasses will coagulate only after seven or eight days.

Experiments in the fermentation of milk by the Walter and Gerber method were less favorable with the product from molasses-fed cows than with normal milk; but these results are far from forcing the conclusion that the milk in question is unhealthy. The quality of the butter is not influenced. The data relating to this analysis show it to be normal, only the butter is a little harder and its melting-point is a few degrees Centigrade higher than other butters. There have been noticed no perceptible differences in the taste of the two products.

Molasses for feeding horses.

Experiments in feeding residuum molasses to horses were conducted by L. Grandeau, who has published an account of same. It is interesting to note in a general way what he says respecting the role residuum molasses could play in feeding not only horses, but cattle in general. Regular weighings at regular hours made known each day the live weight of the horses, during rest, when working and after work. The horses drank at their discretion at given hours, and the water drunk was accurately measured. The weight and the composition of the rations fed were accurately determined, as was also the quantity of food not eaten. Under these circumstances, what each horse had absorbed was known with mathematical precision. The droppings were collected with great care and immediately analyzed. If out of 100 grams of nitrogenous substances fed, 30 grams were found in the urine and excrements, the co-efficient of nitric elements was then said to be 70, this same plan being adopted for all other substances of which the ration consisted. It was found that sugar had the highest coefficient of digestibility under whatever form it was found or fed in the fodder; the coefficient in this case was 100, meaning that all the sugar had been digested by the animal—none was to be found in the droppings. It is interesting to note that for horses of 410 kilos [902 lbs.] live weight the nitric elimination per diem through the hair, perspiration, etc., amounted to about 2.5 grams per diem. This item is mentioned simply to show with what care these experiments were conducted. The daily ambient temperature and conditions of moisture, rain, etc., influencing the experiment were allowed for, and morning and night the temperature of each horse was taken. We cannot in this writing enter into other details; suffice it to say that when the horses were working, they received, beside their regular daily rations, which consisted of straw and oil cake, 2.5 kilos of Vaury's molasses preparation. This represented a little more than one kilo of molasses or 450 grams of sugar. The result of the experiments was as follows:

WORK PERFORMED BY HORSES, MOLASSES BEING FED (GRANDEAU).

WORK DONE.	Empty wagon.	Wagon containing two persons of 70 kilos each.
Velocity per hour	10.38 kilometers.	9.614 kilometer.
Work per hour	248,397 k. m.	254,649 k. m.
Duration of the work	4.23 hours.	4.59 hours.
Distance traveled........	46.431 kilometers.	47.912 kilometer.
Average traction	23.494 kilos.	27 kilos.
Total average work......	1,089,684 k. m.	1,269,000

The amount of water drunk was about three liters per kilo of dry substance of the ration, amounting to a fraction less than that taken with rations without sugar. Contrary to the general supposition, sugar does not increase the thirst of horses. These figures speak for themselves and show that there are great advantages to be gained by feeding molasses to horses during active work.

Jorss has fed horses with forages consisting of palm oil meal and molasses. The animals suffered from colics and presented an unhealthy appearance. He substituted 3 lbs. of cereal waste for 3 lbs. of this molasses combination, and he realized a considerable profit when the accounts of the year were balanced. The horses were in an excellent condition under this regimen.

Respecting molasses feeding, successful experiments may be cited in which broken down horses have been brought to their normal condition by feeding them with chopped straw thoroughly moistened with a solution consisting of 5 quarts of molasses and 25 gallons of water. This mixture was prepared 24 hours in advance of feeding, and to it was added some well-cooked cereal. In certain sections of Germany molasses is fed to the horses of the omnibus company on a very extended scale. The fact is, this molasses feeding to horses is also coming very much into vogue in the German army, and it is only a question of time before it will become generally adopted. In France, also, the question is being seriously considered, and recent experiments apparently show that a satisfactory ration should consist of 15.4 lbs. oats, 11 lbs. clover hay, 11 lbs. wheat straw. During the first few days, about one pound molasses was diluted in water and took the place of one pound oats. This was constantly increased, until reaching the sixth day, when 2.2 lbs. molasses were used and 13.2 lbs. oats, instead of 15.4 lbs., as per regular ration without molasses addition. The results obtained were in every way satisfactory—there was a slight increase in the horses' weight, without in any way diminishing their power for work.

The molasses fodders are decidedly advantageous, especially for working horses, and Kunze claims that molasses, when properly used, will give them great vigor during excessive working. It will quicken their appetite, even in case of animals that are poor feeders. One may feed 1.5 to 2.5 kilos per diem, which means 1.2 to 1.9 kilos of molasses. The hair of the animals fed retains its glossy hue, and their general health gives reason to believe that the product is to be highly recommended in every respect.

Sheep feeding with molasses.

Albert and Ramm have obtained excellent results with sheep, and the health of the animals being fed has remained quite satisfactory by feeding 3.6 per cent. of the animal's live weight combined with barley. Greater amounts, such as 4.8 per cent. to 5 per cent., brought about some digestive complications. There has never been noticed the slightest increase in wool production.

For sheep being fattened one may give a ration in which there are 250 grams molasses. This feed should never be used for these animals during the period of gestation.

Sheep thrive on molasses, but there is one objection to molasses feeding in the case of sheep, which is that the wool becomes soiled; this, however, can be thoroughly remedied by washing.

Steer feeding with molasses.

It is interesting to observe which live stock is the most benefited by this molasses feeding. For steers being fattened during the summer, 4 kilos per 1,000 kilos live weight are sufficient, while in winter 6 kilos are necessary. When this limit is reached, certain softening of the bony structure is noticeable, which, according to several leading authorities, is to be attributed solely to molasses, and the explanation given is its low percentage in phosphate of lime and also the formation of certain acids in the digestive tubes, due to the sugar it contains. This acidity decreases the alkalinity of the blood, which then dissolves the calcic phosphate.

This difficulty may be overcome by adding 50 grams of precipitated phosphate, as suggested by Maercker. Experience shows that since this product has been used there has not been a single instance of bone softening; consequently, when 4 kilos of molasses are given to a full-grown ox, it is desirable to add to the ration at least 100 grams of calcic phosphate per 1,000 kilos live weight.

Vibrans has obtained excellent results with working oxen, and claims that no other feeding substances can take the place of molasses. His manner of feeding is to chop hay very fine, combine it with straw, and sprinkle the whole with molasses. Concentrates are thrown over this and subsequently mixed.

At the Hohenau sugar factory (Germany) they have been feeding these molasses forages to oxen for more than twenty years. During the first month 1½ kilos per head and per diem are fed, and the following months 2 kilos of molasses are mixed with cossettes in the daily ration. It is recorded that the animals had a better appetite and were rapidly fattened. From what has just been said, we may conclude that steers and oxen are very much benefited by this molasses feeding.

A question that is open to much discussion is that of influence of molasses combinations upon the ultimate quality of the meat. Experiments were made at Leipzig (Germany) upon steers fattened at Lauchstädt with the following ration for the first group: 5 kilos hay, 8 kilos straw, 8 kilos dried cossettes, 6 kilos peat molasses, 6 kilos bran, and 3 kilos cotton-seed meal. The second group received 5 kilos hay, 8 kilos straw, 8 kilos dried cossettes, 12 kilos bran-molasses combination, and 3 kilos cotton-seed meal. The cattle were subsequently slaughtered and their meat was pronounced of first-class quality.

On a French farm visited by the writer, the ration for steers weighing 320 to 350 kilos was 10 kilos wheat middlings, 3 kilos molasses, 3 kilos crushed barley and 1 kilo oil cake. After fifty days' feeding the steers were in an excellent condition. There can be no doubt as to the possibility of substituting oil cake for residuum cossettes, but it must be done gradually.

Pig feeding with molasses.

Very little data has been published respecting experiments in pig feeding, but those that are known may, upon general principles, be considered favorable. For example, Jorss records that after seven days feeding of two pigs with 2 kilos of molasses per diem there followed an increase of weight corresponding to 835 grams per diem on an average. This authority is an advocate of liquid molasses, and recommends it in this form for pigs. It must be diluted with two to three times its volume of hot water, to which is added some cereal waste, the whole being left in a heap in that steeping condition for 24 hours.

Experience shows that it is not desirable to feed pigs with molasses until they weigh at least 50 kilos. When this weight is reached one may feed 1 per cent. of their weight of this product. Sows, on the other hand, should not be allowed more than 0.5 per cent. Molasses produces an excellent meat when fed at the same time as corn, and under no circumstances should it ever be lacking in a pig-feeding establishment. However, certain precautions are necessary so as not to push this quantity to an excess, as in reaching a limit of 3 per cent. there are dangers of intestinal complications, which means an impossibility of sausage-making.

According to Miesol and Bersch, the non-sugar of molasses takes a great part in the phenomenon of assimilation, as experiments with 1 kilo of molasses upon pigs showed when compared with sugar and starch fed under like circumstances. Both the meat and the fat were of excellent quality.

Fay and Frederikson have fed pigs with skimmed milk and beaten milk, and likewise milk waste. As soon as the animals reach 25 kilos in weight the forage consisted of barley, corn, pollen, oil meal, one-third flour, and two-thirds molasses. The amount of forage molasses fed was increased so as to constitute one-third, one-half, or even two-thirds of the ration, but experience showed that the increase of weight was not proportional to the increase of the amount of molasses fed.

Experiments seem to show that molasses will not take the place of grain in feeding. However, the quality of the fat and of the meat of the pigs increased very materially under molasses feeding.

As a general thing the animals increased in weight in a very marked degree. Experiments furthermore appeared to show that molasses contributed to the excellency and superiority of the resulting hams.

Pernicious effects of molasses feeding.

For a long time past it has been pointed out that molasses feeding was generally followed by miscarriage in the case of pregnant cows, and the mortality among calves fed with molasses was exceptionally high. Efforts were made to determine the reason, and Friske declared that it was the outcome of a special acidity that calves brought with them when born. Kopisch maintained that the milk soured in the stomach of young calves, and was changed into cheese. He even went so far as to feed the young animals with milk of lime to dissolve this cheese. But Lachau showed that the death rate was caused by the infection of the environment, and that it was sufficient to change the locality in order to decrease this death rate. It may, however, be attributed to a decrease in the percentage of molasses in the ration. It has been noticed that the most difficult problem to overcome was to convince the breeder that exaggerated quantities of molasses were harmful—the farmer always feeds this residuum in excess of what should be given. Even 5 kilos per head, Ramm declares, is an exaggerated allowance for milch cows. Certain complications, such as fever and tremblings, have followed when this amount has been exceeded, and even when reaching this limit great care is necessary, for several instances are on record where certain signs of weakness were apparent; the bony structure underwent some changes which were attributed to molasses, and which were explained by the small percentage of phosphoric acid and lime the residuum contains, and the formation of certain acids in the digestive canal.

It was suggested by Maercker that 50 grams of precipitated phosphates per head and per diem be added to the ration, and since the advice was put into practice there has never been a complaint about any weakness resulting from the molasses-cossette feeding. Some agronomists declare that it is advisable, when feeding more than 4 lbs. molasses (per 1000 lbs. live weight) per diem, to add 100 grams of a basic phosphate to the ration per 1000 lbs. live weight of full-grown oxen.

Molasses has an exciting influence on the organism of animals in general. The appetite is increased for the consumption of other fodders, and in this way it renders great service in the case of animals that decline to eat, as often in cases of momentary sickness they will eat molasses forage when they will refuse everything else.

Nutritive value and variations of molasses.

As regards the nutritive value of molasses, it is difficult to obtain exact data. It has been compared with oil cake from various sources. Further on its effects will be shown.

Its action upon animals in general has resulted in certain complications, which, as a rule, have been the outcome of faulty modes of its usage. This action has generally been attributed to the alkaline salts producing undoubted purgative effects. If we may rely upon the observations of Hoppe, we should consider the alkaline saccharates responsible, and above all the potassic saccharates, rather than the potassic salts, properly speaking. Diarrhoea has been obviated by estimating exactly the quantity of molasses fed, and giving to the animals other suitable feeds at the same time.

Evident beneficial effects.

Experience further shows that molasses-fed animals have an excellent appearance; this is especially so in the case of horses. The horses' coats, under these conditions, have a brilliant hue. Molasses has, furthermore, a special action upon horses; it cures colics permanently.

Practical comparative experiments in molasses feeding in France.

In certain districts of northern France recently visited by the writer, molasses has been given some practical tests in horse and cattle feeding. The horses had previously been fed with 26.4 lbs. of oats per diem; this was worth 41 cents. At the present time each horse consumes 22 lbs. of oats, worth 34 cents, and 6.6 lbs. of molasses, worth about 4.8 cents, which means a saving of about two cents per diem upon each animal fed; besides which it was noticed that horses under the molasses ration were in a far better condition, had better appetites and were entirely free from intestinal complications. The molasses is always combined with two or three times its volume of water.

In fattening oxen it was found that molasses offered an economy of 1½ cents per diem as compared with other rations. The 13 oxen fed with pulp and molasses gave a total weight of 14,630 lbs.; 13 other oxen fed upon residuum pulps and oil cake, weighed 22 lbs. more; this was after first weighing. But when weighed twenty-two days later, it was found that the molasses-fed had gained 143 lbs. over the others, the weight of residuum pulp fed in both cases having been the same. The method of feeding the molasses offers special interest. The residuum molasses was simply poured on the cossettes prior to each feeding, three times a day. When chopped straw was mixed with this ration, the cattle did not eat it with the same avidity as they did the molasses and cossettes. It is important also to note that in direct contradiction to what is generally supposed, the excrement of oxen fed upon molasses is not more liquid than when fed upon other fodders. Butchers of the locality had no hesitation in declaring that the resulting meat was equal in every way to that obtained with the standard rations.

The above figures are only approximate, and it is important to pass in review some experiments made at Berthonval (France). In every case there were two lots of animals, one lot receiving the molasses ration and the other the regular ration, such as adopted on most of the leading farms. The molasses was used in two ways, either as an addition to a ration or as a substitute of some element. When fed to sheep under the first condition, the daily ration consisted of 10 lbs. of beet cossettes, combined with chopped straw, 1.5 lbs. cotton oil cake, 0.7 lbs. molasses. The mixture was made 24 hours before feeding, so that there followed a slight fermentation, which added to its digestibility and resulted in its being eaten with greater avidity. After 40 days' feeding, the average daily increase in weight was 7.3 ounces for sheep fed with molasses added to the ration, and 5.0 ounces increase with regular ration. In the second experiment the oil cake was replaced by one pound of molasses. Under these circumstances the ration had the same money value at the locality where the experiment was made. The increase per diem for molasses-fed sheep, without oil cake, was 6 ounces, and 5.5 ounces with oil cake. Experiments in feeding heifers were also interesting. The ration consisted of 5.5 lbs. clover, 5.5 lbs. oat straw, 35 lbs. beets cut into slices, 1.8 lbs. oil cake. The first lot of heifers received 1.5 lbs, of diluted molasses combined with the cossettes 24 hours before feeding. In this case the daily increase of weight was 2 lbs. 4 ounces, as compared with 1 lb. 12 ounces on the regular ration. In France, where these experiments were made, considerable money profit resulted from the advantages the molasses offered.

Experiments having for their object the determination of the influence of molasses upon the flow of milk are also most interesting. Notwithstanding the difficulty of the experiment, it was found that molasses-fed cows gave ½-pint more milk per diem.

Experiments in Germany.

The comparative experiments made at Lauchstädt (Germany) were with swine. The first ration consisted of 60 lbs. potatoes, 35 quarts milk skimmings, 17.7 lbs. barley balls per 1000 lbs. live weight; this corresponds to 5 lbs. protein substances, 28 lbs. non-nitric substances. The daily increase in weight was a fraction more than a pound. The second ration consisted of 60 lbs. potatoes, 35 quarts of milk skimmings (mixed with equal parts of barley balls and third-grade sugar), 17.7 lbs. barley balls and 12 lbs. sugar per 1000 lbs. live weight. In this case the daily increase was 2 lbs. The pigs experimented with weighed 110 lbs. to 121 lbs. The pigs were sold at 10 cents a pound, which means that the sugar used at calculations made was worth 5 cents a pound during the first part of the experiments, and if the feeding continued its worth would be reduced 2.5 cents a pound, which means considerable money for a low-grade product. Upon the market no complaint was made as regards the quality of the meat; on the contrary, butchers declared that the hams, etc., were of an excellent quality. During the feeding it was noticed that the pigs were very thirsty, and an important essential for the success was that an ample supply of water be placed at their disposal. It is also important not to give salt during the feeding, as the residuum molasses contains sufficient for all emergencies. About 25 grams of precipitated chalk and 25 grams of phosphate of lime are added to the ration each day.

Varied molasses combinations.

Recently it has been proposed to make a mixture of 40 parts corn-meal cake and 60 parts molasses. This special oil cake is very rich in protein, and naturally constitutes a valuable nutrient. It has since been proposed to mix 75 parts molasses and 25 parts peat. In France this molasses combination costs about $1.60 per 100 kilos (about 73 cents per 100 lbs).

Three popular combinations are as follows: (1) 2 parts molasses; ½ part wheat bran; 1½ parts flour. (2) 2 parts molasses; 3 parts malt sprouts. (3) 2 parts molasses; 3 parts rice flour.

As regards the last mixture, it is interesting to call attention to the fact that according to Briem, rice flour is not suitable for the preparation of a molasses forage. For horses he recommends especially two parts molasses, three parts oat waste; for swine, two parts molasses and two parts lentil waste.

Weiske manufactures a forage containing ⅓ molasses, ⅓ wheat bran, ⅓ fish powder. Under these circumstances he obtained a forage rich in nitrogenous substances and possessing a heavy percentage of calcic phosphate.

As a synopsis of the action of all the forages named, one need only pass in review the experiments of Gerland with molasses forages, which had the following compositions:

MOLASSES FORAGES (GERLAND).

Molasses, 50 p.	Molasses, 50 p.	Molasses, 50 p.	Molasses. 80 p.	Molasses, 40 p.
Palm oil cake, 50 p.	Bran, 50 p.	Distiller's mash,50 p.	Peat, 20 p.	Corn sprouts,40 p.

The experiments were preceded for fifteen days by a preparatory feeding, so as to accustom the animals, little by little, to the standard combination upon which they were to live during the period of the experiment. The experiment proper lasted ten days. The sheep were fed three times a day. They received first an intensive forage, then a ligneous forage with the remains of the intensive forage. In the morning water was allowed at will, and during the first days they were permitted to run around the stable for a quarter of an hour. All these rations are calculated upon a basis of 1,000 kilos live weight. The increase in weight per individual during the ten days with different combinations varied from 0 to 0.7 kilos.

The preparations experimented with were accepted by the animals fed with one exception, and this was possibly due to the fact that it contained cacao wastes, which are bitter. Another ration resulted in a violent diarrhœa. It contained 4.8 kilos of molasses for 1,000 kilos live weight, while the others, of which the effects were not unfavorable, contained only 4 kilos of molasses. With this molasses forage sheep were in a most excited condition, which is contrary to the observations of Ramm, who has never been able to notice an unfavorable influence upon the animal or its wool from molasses feeding.

The increase of weight caused by a kilo of sugar consumed represents in value 54 pfennigs (about 5 cents per lb.), but sugar in the molasses is only worth 14 pfennigs (about 1½ cents). Consequently the feeding with molasses may be considered very lucrative, while feeding with sugar is supposed to be quite the contrary.

Desirable limits in molasses feeding.

The quantity of molasses it is possible to feed depends partly upon the suguar it contains. The salt constituents of such molasses do not all possess the same action, and are not contained in all molasses in the same proportion. Hoppe has noticed that acid molasses gives far better results in feeding steers than when the residuum is alkaline. The forage added to the molasses during feeding also has an important influence and brings about very varied results. The general nature of the animal fed is also a factor to be taken into consideration.

Herewith are the quantities recommended by some authorities:

VARYING MOLASSES RATIONS FOR DIFFERENT ANIMALS.

Animals fed.	Briem.	Schende (Germany) sugar factory.
Working oxen per 1000 kilos live weight..	3 to 4 kilos.	
Growing steers per 1000 kilos live weight..	4 to 6 kilos.	Commence with 2 lbs. then 3½ to 4 lbs.
Milch cows per 1000 lbs. live weight......	2½ lbs.	Commence with 2 lbs. then 2½ to 4½ lbs.
Milch cows, during gestation, per 1000 lbs. live weight......	½ lbs.	
Growing sheep per 1000 lbs. live weight...	½ lbs.	Commence with ¼ lb. then ½ lb.
Lambs per 1000 lbs. live weight	¼ lbs.	
Full grown heavy sheep..................	....	½ lb.
Horses..	....	Commence with 2 lbs. then 4 lbs.

For swine commence with ¼ kilo per 1000 kilos live weight and gradually increase to 1 kilo.

The selection of feeds to be given at the same time with molasses should be made with care, always allowing for the special properties of each of them, to say nothing of their market prices.

Making allowance for their price upon the market and their nutrients, they may be classified as follows: molasses and palm oil cake, wheat bran and molasses, distillers' waste and molasses, peat and molasses, corn sprouts and molasses, cossettes and molasses, and finally, but far down in the scale, is sugar from the first strike of the pan.

It is for the breeder to determine from experience what combination is best suited to his animals. Opinions differ very much as to the manner of absorbing the molasses and the ingredients that are to be used for this purpose.

Money value of molasses.

If the question is considered on a mathematical basis, taking existing prices of fodders and their unit value based upon the valuable nutritive elements they contain, it is shown that in France molasses would have to sell at $14.40 per ton, to actually cost more than rice flour, and even then it would be possible for the residuum to compare favorably, dollar for dollar, with wheat and rye brans. Prof. Grandeau says, even admitting both costs to be the same, that molosses has within itself a superiority for feeding purposes, as the non-nitrogenous elements, as previously explained, are superior, owing to the high percentage of sugar entering into their composition. It is for the farmer of each locality, either in California, Nebraska or elsewhere, to determine just how it may be to his pecuniary advantage to carry the residuum from factory to the farm.

Classification of molasses feeds.

Molasses may be used for feeding purposes in several different manners: (A) In its raw state; (B) Combined with dried or pressed cossettes; (C) Combined with some absorbent such as peat, bran, etc.; (D) Combined with blood, (E) In various combinations baked in an oven, and (F) Bread molasses.

Diluted and combined molasses for feeding.

Molasses may be fed to cattle in two forms: either in a liquid state or mixed with a feed. They both have certain advantages as well as disadvantages, and it is for the farmer to determine his preference. Molasses may be diluted in water and fed as a drink; or it may be sprinkled over a forage such as chopped straw. Molasses is not readily dissolved in cold water, and therefore solution is effected mainly in hot water. For dilution, warm water may be used, either with or without steam, and after being carefully measured, it is emptied into the feeding trough.

It has been proposed, in order to avoid the use of warm water, that the molasses be placed in a small bag, and that this be suspended at night in the trough from which the animals drink. The molasses will gradually pass through the bag and will slowly ooze out in thin streams, which readily dilute at the bottom of the receptacle containing the water, it being sufficient to stir the liquid slightly in the morning in order to obtain a homogeneous solution. One may also dissolve molasses in distillers' mash in cases where this special residuum is used in cattle feeding.

The diluting of molasses is considered excellent, for the simple reason that the animals being fed become gradually accustomed to this new regimen. But while diluted molasses feeding may be economical, it is upon general principles a mistake, and has many inconveniences. Its transportation is both difficult and unpleasant. The mixing of same with feeds is also no easy operation, and a trough in which it is poured can be subsequently over-charged with micro-organisms of various kinds that ultimately cause sickness.

Without doubt molasses residuum as it leaves the sugar factory would be very unpleasant, and consequently not acceptable to live stock in general. It is sticky in its nature and adheres to everything with which it comes in contact. All receptacles in which it is handled have to be washed with hot water before becoming properly cleaned, which offers no difficulty where the water and steam may be had *ad libitum*, but would prove a question of difficult solution for the smaller farmer.

Notwithstanding the fact that the use of molasses preparations is becoming more and more general, it is apparently the direct manner of feeding, without preliminary mixing, that still continues in vogue in Germany, Austria and Sweden. However, molasses combinations have, without doubt, great advantages, as they may be readily handled, and are moreover possessed of considerable keeping power. The use of molasses without mixing, in the long run, would cost more, and when taken alone there is always danger of diarrhoea; but there are many exceptions to this rule.

Diluted followed by concentrated molasses for digestible forage.

Some years since it was claimed that it was possible to form with molasses a readily digestible combination for live stock feeding. Among the advantages claimed was that of overcoming the diuretic and laxative effects of molasses, due to its excessive salt percentage. The feeds of the combination are submitted to a preliminary treatment. For example, when saw-dust is combined with molasses, before the object aimed at is realized a large quantity of herbs must be used, and in order that the bitter constituents contained in the herbs shall become active, the product is submitted to a sort of preliminary steeping in diluted molasses. It is claimed that whereas concentrated molasses or syrup may be considered antiseptic in its action and will consequently arrest fermentation, a diluted solution of molasses on the other hand will hasten fermentation. Consequently, as soon as herbs which contain the essential sour substances are steeped in diluted molasses, there follows an acid fermentation, which tends to destroy the glycosides, at the same time liberating the active elements of the plants; now if this is followed by a concentrated molasses treatment, there will result specific advantages from a nutrient standpoint, during the action of digestion. The practical working of this mode consists in using an herb rich in glycosides, which is chopped up dry and moistened with a 1 per cent. solution of molasses. The mixture is left for several days at the ambient temperature, and $\frac{1}{20}$ to $\frac{1}{50}$ concentrated molasses is added to it, which has been previously mixed with some fibrous substance, saw-dust, chopped straw, and finally with lime.

During the first phases of fermentation, instead of using the sour herbs alone, 5 to 10 per cent. of saw-dust may be added to them before starting the fermentation with diluted molasses, which will then be unusually active. The main feature of this mode consists in bringing about a decomposition of the glycosides by fermentation through the intervention of diluted molasses.

Proskowetz pours concentrated molasses over forages and then does the mixing with suitable pitch-forks. With this combination he has fed 1½ to 2 kilos of the residuum per diem to sixty steers, while fifty other steers were fed with the ordinary rations. The experiment showed that there was an increase of one-fifth kilo per diem for the molasses-fed animals.

Ramm undertook a very interesting series of investigations of feeding milch cows with liquid molasses. Twelve animals were fed with rations consisting of 10 kilos hay, 3 kilos wheat middlings, 50 kilos of forage beets, 4 kilos flour, and 8 kilos of molasses per diem per 1000 lbs. live weight. The molasses was heated to 70° C. and spread over the forage. The total was thoroughly mixed, and the product was eaten with relish. Experience appears to prove that when a cow does not derive any benefit from this feed, there are no known means by which the animal may be accustomed to even diluted molasses. These experiments showed that this residuum was most excellent for the production of milk: its percentage of dry and fatty substances increased, and the milk and butter were absolutely normal.

It is interesting to note that the conclusions from these experiments were to a certain extent in contradiction to previous observations made by the leading agronomists, viz., when this molasses forage combination was fed to cows during gestation, and even after the calf was born, no evil effects followed, either for the cows or for the calves.

Hoppe discussing this question has declared that the health of the animals fed was most excellent, and no digestive complications were noticed, even when seven months had elapsed from the time of pregnancy, and 5 kilos of liquid molasses were mixed with concentrates per 1000 kilos live weight. According to this authority the laxative action could not be attributed to the salts, but to the saccharates, and especially to saccharate of potassium. With the other cows fed, that were not undergoing this period, the result was that there was a simple increase of milk without augmentation of weight. On the other hand it is claimed that a milch cow fed with the molasses combination during gestation will subsequently not only give more milk, but will also increase in weight under this special residuum feeding.

CHAPTER II.

Molasses Cossette Combinations.

Cossettes, fresh and dried, mixed with molasses for cattle feeding.

THE cossette-molasses forage is most important for the sugar industry. This feed is prepared in two ways, either by using dried cossettes with the molasses, or moist cossettes as they leave the presses, the combination in each case being heated.

The first method is not practicable, because, as the molasses combines only with great difficulty with dried cossettes, the mixture is very difficult to realize without the use of a special machine for grinding a large portion of the cossettes.

The dried cossettes, however, constitute an excellent combination with molasses by mixing them in the proportion of from 5 to 6 parts molasses for 100 parts of this dried product. The average composition of the combination is: Water 8.5, protein 8.7, cellulose 14.0, fatty substances 0.3, non-nitrogenous 62.0, ash 6.5.

Wusterhagen adds pressed cossettes to both hot and cold molasses and subsequently submits them to drying. It is rational to mix these two products in the same proportions as they are obtained at the factory. Under these conditions one obtains for 100 parts of dried cossettes six to seven parts of molasses, sometimes ten. Under all circumstances it is desirable not to use an excess of molasses in order to prevent the combination from being sticky. Werner and Pfleiderer have a special apparatus for this mixing, which is heated by steam and in which dried cossettes may be combined with molasses under satisfactory conditions.

This forage is now recognized as a staple commodity in Germany. Its average composition is about as follows:

	Per cent.
Moisture	80.1
Ash	6.47
Fatty substances	0.40
Nitrogenous substances	8.77
Cellulose	17.61
Non-nitrogenous	60.31

Molasses and dried cossettes have a more favorable action upon the organism when considered from a general point of view than has molasses when fed separately; furthermore, owing to the more or less resisting texture of the residuum in question, the substances that fill the digestive canal have greater consistency, which is certainly an advantage, as it obviates all possibility of diarrhœa that molasses in a certain degree always creates. It would thus appear that molasses increases in certain cases the assimilation of the nitrogenous substances of the cossettes, and one may notice, with this forage, an important augmentation in the weight of the animals to which it is fed.

Molasses cossette preparation in diffusion battery.

Natanson has attempted to prepare molasses cossettes in an entirely different way. While this method has never been practically accepted, it is, nevertheless, interesting to give it a passing notice. Into the diffusors proper, containing the exhausted cossettes, molasses is introduced in a more or less diluted form. The sugar that it contains passes, by osmosis, into the interior of the cells of the cossettes and accumulates in increasing quantities. The operation is stopped when the excess of molasses in the cossettes is such that the compound contains 63.47 per cent. of carbohydrates, of which 41 per cent. is saccharose. According to Petermann these cossettes will keep for a period of six months without undergoing the slightest change.

Molasses and dried cossettes in combination.

Strohmer says that a good mixture may be obtained with 2 per cent. dried cossettes, 10 per cent. water, and one per cent. molasses heated to 40° C. After cooling and having remained for several days in a cold environment, the product can be put in bags, or it may be pressed into cakes, the form in which many of the staple oil meals used in cattle feeding are often found on the market. In some cases it is found desirable to grind the dried cossettes before mixing. Many of these dried cossettes and molasses combinations are patented.

The preparations of dried cossettes and molasses mentioned above, correspond to the production of 2.5 residuum molasses after a sugar campaign. Herewith are the analyses of some molasses and dried cossette combinations, according to the best German authorities:

Analyses of Molasses and Dried Cossette Combinations.

	Per cent.	Per cent.	Per cent.
Water	7.67	5.77	9.00
Nitrogenous substances	*10.00	†9.65	‡8.9
Fatty substances	0.85	0.70	0.35
Sugar	23.09	11.98	20.20
Non-nitrogenous	39.33	49.17	39.25
Cellulose	12.40	17.17	14.40
Ash	6.37	5.42	7.60
Silica	0.30	0.14	0.30

* Six per cent. protein. † 6.45 per cent. protein. ‡ 5.65 per cent. protein.

Increase of weight from the start.

The dried cossettess and molasses constitute an excellent forage, and the only one, according to Ramm, which will give from the very start of its feeding, an increase in the weight of the animals fed. This is just the opposite result obtained with most beet-molasses forages, as during the early days of feeding there is generally an incomprehensible decrease in weight.

A well-known expert declares that the molasses and dried cossettes never form gases in the intestinal canal, which are always to be dreaded with palm oil meal.

The influence upon milk production is very considerable, and much more so than is that of liquid molasses feeding.

Dried cossettes and molasses better than pressed cossettes and molasses.

The experience of Olschbauer, who undertook a series of comparative experiments with milch cows, one series being fed with molasses and dried cossettes and the other with pressed cossettes, demonstrated that the best results were obtained when the cossettes were dried, provided, however, that the residuum product could be had at a reasonable price.

Satisfactory results have been obtained by mixing the pressed residuum cossettes with molasses before siloing; but this mode is not to be recommended on account of the excessive fermentation that is sure to follow.

Early experiments with peat molasses feeding.

Wagner attempted to overcome the action of potassic salts upon the digestive system and at the same time give molasses certain keeping qualities by mixing it with peat.

Among the early practical experiments in the peat-molasses combinations may be mentioned those in Sallschutz (Austria) in 1895, which were the outcome of the exceptionally high selling price of farinaceous products. The early mixtures consisted of molasses containing 48 per cent. sugar, to which was added oil meal. This proportion was later changed to 40 parts oil meal and 60 parts molasses. The addition of molasses to other feeds was abandoned after several experiments. The 60 per cent. molasses fodder had the following composition: Water 21.4 per cent., nitrogenous substances 11.1, fatty substances 0.7, non-nitrogenous 53.5, of which 28.8 per cent. is sugar, 6.7 per cent. cellulose, and 6.9 per cent. ash.

The peat-molasses combination became popular in 1896, when 20 parts peat were combined with 80 parts molasses. This combination contained 38 to 40 per cent. sugar, and the product sold for 80 cents for 220 lbs., or ⅓ cent per pound.

The peat absorbs the molasses, so that the ultimate forage is very uniform. The acids of peat neutralize the salts of molasses and render them harmless when fed. The peat used should be fine in texture and possess a very considerable absorbing power. This pulverized product can absorb, according to Schwartz, three or four times its weight of molasses without losing the advantage of forming a combination that may be easily handled.

Experience shows that for practical purposes the best results are obtained by mixing it with twice its weight of molasses. Under these circumstances one obtains, according to Weigmann, a forage having the following composition:

	Per cent.
Water	24.85
Protein	8.34
Fatty substances	0.87
Ash	7.54
Cellulose	5.80
Non-nitrogenous	52.60

Dr. Albert says there follows a considerable increase in weight, much more than can be obtained with bran-molasses combinations, and that it is, in every way, far superior to liquid molasses.

Peat and molasses better than bran and molasses.

In the investigations that were made at Lauchstädt, Germany, it was noticed that in a mixture with bran or peat, the molasses gave a better result than in its raw state, which was evidently explained by its better sub-division. The advantages to be thus gained more than compensate for the expenses of its manipulation.

The advantage of this forage is that it is gradually absorbed in the digestive canal and the constipating action of peat is thus counterbalanced. The influence of potassic salts is no longer felt. One would especially notice the advantages of these properties if it were fed at the same time as beet leaves.

Peat, thus absorbed, has the advantage of increasing threefold the amount or quantity cf molasses possible to be fed to live stock per diem.

Possible intestinal complications through peat-molasses feeding.

Some investigators declare that peat causes intestinal troubles, and can, furthermore, owing to its power of absorbing moisture, bring about dangerous inflammation. The question is frequently asked, Will intestinal complications not follow the feeding of peat, a product that is in reality indigestible? This has not proved to be the case, and very few complaints have been made. If four pounds of peat-molasses are fed, the quantity of the indigestible powder passing through the alimentary canal is only ¼ lb., which is so small that it need not be considered.

Doctor Albert has made post-mortem examinations of animals fed upon this peat-molasses combination up to limits of 4 kilos per diem, and declared that these assertions are very much exaggerated, as he has been unable to trace the slightest inflammation of the mucous membrane of the intestines. He has, moreover, been unable to find any peat deposits in the intestines.

According to Jorss, it is precisely to the peat's power of absorbing moisture that the advantages of this fodder are due. The experiments of Albert have only demonstrated, in a practical manner, the advantages of this forage, and it is now being used with great success in the cavalry of Germany, Austria, Belgium, Denmark and Russia.

Digestibility of peat.

In the experiments in cattle feeding made at the Moecken agronomic station, the main object in view was to determine the coefficient of digestibility of peat, and it was concluded that the product is indigestible; which means that it passes through the alimentary canal without being assimilated, and its presence diminishes the digestibility of the other elements of which the fodder is made up. From a practical point of view, peat has no money value; but this conclusion differs from that of many other investigators, and for this reason a few hints respecting the manner in which the experiments were conducted are of more than passing moment. Sheep were first fed with hay alone, with hay and molasses, and with peat-molasses combinations. The coefficient of digestibility is obtained by comparing the amount of sugar, nitrogenous elements, starch, etc., contained in a given quantity fed to an animal and that thrown out and found in the excrement. If 100 grams of starch were fed and 35 were found in the excrement, the coefficient of digestibility would then be 65. This is by no means a constant quantity, for it can be made to increase or decrease by the addition of other substances, as is the case with peat-molasses combinations, and the digestibility of hay was very much reduced by the presence of peat. The averages of these experiments were as follows: In the peat there were 200.6 grams organic substances; 12.2 grams nitrogenous substances; 112.1 non-nitrogenous substances; 4.9 raw fat; 71.3 raw cellulose, and in the excrements there were 216.5 grams organic substances; 19.6 nitrogenous substances; 122.1 grams non-nitrogenous; 4.1 grams raw fat, and 69.9 grams raw cellulose. These figures show that there was more nutrient thrown off than the peat contained; consequently it was drawn from the hay, which is an actual money loss. Hence the agronomist who undertook these experiments concludes that peat does not offer for the purpose the advantages claimed, and some other substance should be combined with the molasses residuum when cattle feeding is the object sought.

Consequently it is very justly concluded that peat within itself does not possess any nutritive value, but diminishes the feeding properties that would have otherwise existed.

Opinions differ as to the value of peat-molasses for feeding.

Great variance of opinion exists as to the nourishing value of the peat-molasses combinations; for example, Maercker says that it has the same nuritive value as molasses and wheat bran; Jorss asserts that weight for weight it is equivalent to wheat, and that, furthermore, it is much more economical, the appetite of the animals fed increases, and there are no evidences of colics.

Certain authorities, such as Gerland, Hassen, Vibrans and Keller, do not favor peat-molasses. They argue that when purchasing peat-molasses one pays for not only the price of the molasses, but also for the peat, which is simply ballast, and does not contain protein. One is obliged also to pay for the manual labor for the mixing and other expenses.

Kellner, Zahn and Gillan show that peat, instead of possessing a nutritive value, carried out with the excrements small quantities of nutrients that would have, or at least should have, been taken up or assimilated by the animal fed. Molasses fodders gain nothing in nourishing value by being combined with peat; hence it is urged that this product is simply a useless ballast in the stomach.

Conclusions as to value of peat-molasses for feeding.

Peat offers advantages in more ways than one, and after weighing all the arguments for and against this so-called ballast in the stomach, combined with our personal observations, the conclusion is drawn that up to the present time but few substances have been found offering the advantages of this product. It is important, notwithstanding, to pass in review the various arguments brought forward.

All the molasses fodders proposed and used have one advantage, they are very simple, and the farmer with only a very limited knowledge of the essentials for cattle feeding, may combine his rations so as to obtain most satisfactory results. Peat, as used in France, has the following composition: Water 18.90 per cent., ash 2.32 per cent., cellulose 13.20 per cent., pentosane 8.83 per cent. black substances 14.40 per cent. (containing 5.13 per cent. nitrogen), various nitrogenous substances (averaging 6.25 per cent. nitrogen) 1.80 per cent., unknown substances 40.5 per cent. A fact not generally known is that the nitrogenous substances of peat are those black elements which are soluble in ammonia. Experiments under special official auspices have shown that when they are submitted to artificial digestion the nitrogenous elements remain inactive; for 1.3 total nitrogen there was only 0.08 that had become soluble. The other elements of peat are apparently not assimilated, and if they offer no objectionable features during their absorption, comparatively little fault may be found with their use. That it is a ballast appears a secondary consideration as compared with the advantages it offers as a wonderful molasses absorber. The Toury peat molasses combination has the following composition: Water 19.00 per cent., ash 8.91 per cent., sugar 31.70 per cent., various soluble substances 20.93 per cent., insoluble substances 19.46 per cent. This molasses fodder consists mainly of 24 per cent. peat and 76 per cent. slightly steam-diluted molasses. Experience has shown that horses eat it with avidity, and in every respect there are striking advantages to be derived from its use. The nitrogenous substances it contains are those black compounds before alluded to, and they may, with the amides, be considered as the calorific elements and be added to the carbohydrates. Experience in France has shown that the total cost of 100 kilos of this forage, as delivered at the factory, is one cent per pound or one dollar per hundred pounds. As an example of a practical ration for horses per 1000 pounds live weight, may be mentioned crushed wheat 7.65 lbs., hay 6.00 lbs., wheat bran 1.50 lbs. In France this ration costs about 50 cents. It has been found advantageous during June only, due to the special climatic conditions found in the country, to substitute another ration consisting of crushed wheat 3.4 lbs., peat molasses fodder 3.00 lbs. and hay 6.0 lbs., costing about 32 cents. After July the ration consists of crushed wheat 3.37 lbs., peat-molasses 3.5 lbs., hay 6.5 lbs.

At the Toury factory this ration appears to offer considerable economy, amounting to over fifty dollars per horse per annum. Furthermore, the horses were kept in a most healthy condition. No colics followed, and their appetite continued good throughout the period of feeding.

The molasses-peat combination should be sold at a reasonable price, so as to be within reach of all; its market price should vary with that of molasses, and the salts of which it consists, to which must be added the cost of manufacture. It possesses special keeping powers, for even after several months the sugar percentage of the product does not decrease.

The mixture of molasses with peat is rapidly attaining an important place among the standard fodders. Wagner dries the peat obtained from moss, which is found in considerable quantities in northern Germany. Under the name of "molassion" it is used in the German artillery for feeding horses, and it has become very popular.

Varied peat molasses combinations.

The Krantz-Boussac combination is very original and deserves to be considered. It consists in utilizing skimmed milk in conjunction with molasses. The great difficulty has been the transportation of the product, which was increased by its tendency to sour after a few days. A new combination consists of molasses, peat meal and skimmed milk. Experience seems to show that skimmed milk in the combination just mentioned will no longer sour, is a solid product and may be easily handled. It would appear that the salts contained in the residuum molasses combined with the antiseptic principles of the peat prevent the lactic acid reaction; the product under consideration is made up in various forms.

Feeding peat molasses to horses.

Some data has been received said to come from one of the officers in the German army, who has been making some important experiments in feeding horses with a compound of molasses and peat which has proved to be highly satisfactory. It is claimed that the fodder increases the animal's appetite, facilitates digestion and gives the hair of horses a brilliant lustre; colics among the animals fed almost entirely disappeared.

At first, the ration consisted of ½ lb. of peat flour and molasses, the quantity being gradually increased to 3 lbs. During the early stages of this feeding the horses refuse it, the black color and odor of the product being evidently not pleasing, but later the compound was eaten with avidity. The standard ration was 3 lbs. of molasses compound per pound of oats. When used as a complementary fodder, about one pound per diem appears to meet the requirements, and may be fed throughout the year. The best results in all cases were obtained with horses that were poor feeders.

At Guhrau (France) the horses all received their regular oat ration and horse beans in which 500 grams of molasses are replaced by one kilo of peat-molasses. After three days' feeding all the animals accepted their new ration, and after eight days they ate it with avidity. Colics and other intestinal complications were not encountered, and the hair and general appearance of the animals were most excellent. During the hard winter work the quantity of molasses allowed was increased to 1.5 kilos.

Feeding peat molasses to milch cows.

Milch cows may be advantageously fed with this product, but certain precautionary measures should be taken, and under no circumstances should it be given to cows during their calving. Later on, the reverse is the case, and there are many authorities to show that it is a mistake to feed more than 1.1 kilo of molasses per diem.

At the Guhrau beet-sugar factory in 1896 the milch cows received 500 grams of palm oil meal combined with molasses, and during the following two years 1.25 kilos cotton seed meal and 2 kilos peat molasses were added to the regular forage. The quantity of milk obtained was all that one could desire.

Hollrung obtained satisfactory results in milch cow feeding by using 2½ lbs. For oxen he used 4.4 lbs., for horn cattle 6 lbs., for horses 2 lbs., and for sheep half a pound per capita.

Working oxen and cattle fed with peat-molasses.

Working oxen have also been very much benefited by one kilo peat-molasses per diem, their ration consisting of cotton oil cake, hay and fermented cossettes, to which were added beet tops. Little by little the peat-molasses fed was increased until 2.5 kilos were added daily to the regular ration; but this amount was found to be excessive and it was reduced to 2 kilos. The oxen had an excellent appearance. For working cattle one may feed without hesitation 1½ to 2 kilos of peat-molasses per 1,000 kilos live weight, and the hydrocarbons that this residuum contains are a great assistance in the work that is to be accomplished.

Young steers may be fed 1.5 kilos peat-molasses per head and per diem. Experience shows that it is a mistake to add molasses to beet leaves, owing to the heavy percentage of salt that the ration would contain.

Pigs fed with peat-molasses.

For pigs no one can doubt the advantages of peat-molasses combinations, and their droppings show beyond cavil that there has been a complete assimilation of this fodder in their digestive tubes. Strange as it may seem, the unpleasant smell noticeable in all pig-sties is hardly perceptible when these molasses combinations are fed, showing that no butyric fermentation has occurred in the digestive canal. One may feed without hesitation 5 kilos of peat-molasses per 1,000 kilos live weight.

It is very important to notice that this combination should not be fed to excess. Schwarts mixes one part peat to two parts of molasses, with boiled skimmed milk, and thus obtains a combination that is easily handled.

Oat flour and molasses combination.

The mixture of oat flour or crushed oats has also some important advantages, and forms when combined with molasses a very valuable forage. The arguments advanced in favor of its introduction are based mainly on the supposed fact that peat is lacking in nutrients and is certainly very indigestible. The manner of feeding the oat flour and molasses renders it readily assimilable and digestible. The manufacture of this product consists in making a hot mixture of oat flour which is allowed to settle and undergo a partial drying, kneading it during the interval. The final product has the aspect of a fine flour and possesses a slightly glue-like texture. An interesting fact pointed out is that the flour-like oat-molasses combination is certainly very much more acceptable to cattle in general than any known peat mixture would be. The combination under consideration contains 23 per cent. fatty substance and protein, and for this reason it is claimed that it is a superior fodder for horses and working oxen.

Molasses has not the same nutritive value as oats, but the desirable proportion of nitrogenous and non-nitrogenous substances in a ration in which these relations are 1.6, can be reached by the addition of a fodder rich in these substances, such as brewers' grains, for example.

Wheat molasses combination.

In most of the existing combinations peat is used to give the molasses compound a dry appearance and thereby to facilitate its handling. Some interesting experiments have been recently made that promise very favorable results. In most countries wheat is sold on the market at prices depending upon its quality and the modes of cleaning it, etc. During the process of cleaning the inferior wheat is separated with other impurities, and is sold separately; and while its market price is much lower than the high grade wheat, it actually competes with wheat and has a tendency to lower the price of the superior article. If these low-grade wheats were combined with molasses they would help the farmer in many ways. The price of good wheat would rise and the inferior wheat would be advantageously utilized both for horses and cows. Experiments show that 3 lbs. of the inferior wheat can take the place of 4.5 lbs. of oats in the ration of a horse, and when brought down to a money basis this means an economy of several cents per diem. The new molasses combination with the flour of the wheat in question has the following composition: Water 5.5, nitrogenous substances 11.8, fatty substances 1.27, sugar 30.05, glucose and dextrin 11.53, starch 22.53, cellulose 19.8, and mineral substances 5.09. These percentages speak for themselves and show the advantages they would offer if used as a fodder.

Corn germs and molasses compared with corn feeding.

Certain authorities have made comparisons between the action of corn germs and molasses and that of corn combined with colza oil meal and wheat middlings so that the total nutritive substances were the same for both. To growing sheep there were fed 7.5 kilos of this germ-molasses product, and 6.3 kilos of corn. The results obtained were favorable to molasses. Schultz obtained with milch cows the same results as could be realized with forage beets and oat bran. These last combinations are most excellent, as every one knows, for the production of milk, and may be replaced by the corn-germ molasses product in cases where beets cannot be had. Albert fed to bulls 4 kilos per 1,000 kilos live weight. This was ultimately increased to 6 kilos. The results obtained were in every way satisfactory.

Wheat bran molasses compared with corn germs.

Dyk compares wheat bran molasses with corn germs, 1½ kilos being combined with ¾ kilo of colza oil meal. In the experiments made the totals of these two forages were substituted for the same weight of bran-molasses; in other cases, gradually commencing by ¼, ½, and ¾, all the forages were finally substituted for bran-molasses. There was obtained an increase of 33 per cent. in the quantity of milk per diem.

Bran and molasses combination.

A mixture that is frequently recommended contains 50 parts bran and 50 parts molasses. The molasses is heated to 80–88° C. before adding the bran and the residuum is rapidly absorbed. Bran may be used in any and all rations.

Bran compared with peat.

Professor Maercker, some time since, undertook some special experiments upon twenty-four steers with the idea of determining the value of the molasses combinations. The animals were divided into four groups, all receiving the same quantity of digestible nutrients per 1,000 kilos live weight, viz.: 3 kilos of digestible protein and 15 kilos of digestible non-nitrogenous substances. Two groups of steers, one in the stable and the other in the yard, received the peat-molasses rations; the two others the bran-molasses ration. The conclusion was that the bran-molasses was superior to the peat-molasses; consequently the high-priced peat product may be advantageously replaced by the bran mixture. However, it was claimed that peat had special physiological advantages, which the leading authorities have never been able to account for.

Moss molasses combination.

Among the original efforts at introducing molasses for cattle feeding is the attempt at combining the residuum with certain mosses of the Sphagnum variety. The important advantage claimed is that the substance in question has the special absorbing powers so much sought after when cattle feeding is the object in view. This moss is composed of nearly pure cellulose. It may be taken from the prairies in its natural state, and grows again almost immediately after a crop is gathered. Before being used the moisture should be removed by means of an ordinary hay press, and the cakes thus obtained be subsequently air dried. It is possible to dry it just as hay is dried. It is delivered to the factory in this desiccated condition, and is then chopped up into small particles and mixed thoroughly, by hand or mechanically, with 6 or 8 times its weight of molasses. It is then stored in a dry loft, and before being fed to cattle is mixed with cereal waste, chopped straw, palm oil cake, corn flour, rice flour, or other substances that the local environment may offer. In order to obtain the cake-like product one pound of moss is mixed with 25 lbs. of any of the substances just mentioned, and molasses added. Attention may be called to the fact that in most of the peat molasses combinations, if the product is pressed between the fingers, the molasses at once oozes out between the pores of the peat, while on the other hand the moss-molasses and palm-oil meal compound may be submitted to considerable pressure without even a drop of molasses coming to the surface. Over two pounds of this product is pressed into a cake and dried at a temperature not above 100° C. An important essential in this instance is that the molasses and moss should be first thoroughly combined and then the other product added; if the order is reversed the compound would consist of dried moss and granules, the feeding value of which would be very doubtful.

Boiling water facilitating the absorption of the by-fodder and molasses.

A German patent for preparing molasses fodder makes the following claim:

A process for preparing molasses fodder, characterized by the fact that substances, such as bran or oil meal, etc., when submitted to boiling water, change their texture so that they may become saturated with molasses. After this treatment, there may be added nutritive substances, such as crushed cereals in varied forms.

The inventor explains that hot water macerates the bran so as to render soluble the sticky or gummy substance with which the pores are impregnated. The molasses, instead of remaining on the surface of the substances, penetrates the pores and forms an intimate fusion with them. This molasses fodder, recommended for horses, is prepared as follows:

Three hundred kilos of rye bran are moistened and left for an hour to soften. Upon this are poured from 500 to 600 liters of water at 100° C. This is covered and left for an hour so that the glue-like substances may have time to dissolve. About 200 kilos of wheat bran are added, followed by kneading for half an hour or an hour, so that the gummy substance from the wheat bran may also be dissolved. There follows a continued stirring, and then about 30 kilos of chopped straw and 30 to 50 kilos of ground oil cake are added, and the product is subsequently energetically kneaded; then about 250 kilos molasses are added. If it is desired to add salt or stimulants this must be effected before the molasses is added, these solutions being dissolved and distributed throughout the pasty product.

After this, cover the mass for an hour or two, to allow the fodder combination time to completely absorb the molasses. Then knead energetically, adding by degrees 150 kilos of crushed maize, 100 kilos of crushed barley and 100 kilos of crushed oats, which results in a consistent pasty product. The latter is now left for 2 or 3 hours and is then cut into pieces, which are run through rollers to be made into cakes 10 to 15 mm. thick, and subsequently dried. The mass is then ready to be used as a fodder.

The inventor claims that these ground cakes, prepared with the ingredients and in the proportions indicated, form a complete fodder on which an animal, if need be, could be exclusively fed. As the fodder already contains chopped straw, there is no necessity for additional constituents. It is important to follow the operations in the indicated order, and it is also essential that the different substances be thoroughly mixed.

Glucose and rice flour molasses combination.

The Delattre molasses combination, while it was introduced several years since, has not met with the success that was hoped, notwithstanding the fact that it has many very valuable characteristics. Up to the time that it was introduced the main use of molasses in cattle feeding was simply for sprinkling hay and forages, but the residuum was never considered as an actual mainstay in feeding. In this Delattre method, it was claimed that molasses was the mainstay, the basis upon which the feeding depended. The composition consisted of 100 parts glucose and 50 parts rice flour combined with molasses. These combinations undergo certain variations, but in all cases the ingredients introduced are such as to keep the general proportions of the constituents about the same, viz.: Proteids 26.7 per cent., fatty substances 5.40 per cent., carbohydrates 21.16 per cent., sugar 20.82 per cent., water 12.45 per cent., ash and cellulose 13.44 per cent.

Feeds sprinkled with molasses and heated under pressure.

Not long since A. Guttmann addressed a German agricultural meeting on molasses feeding, and as he has given the product a practical trial during a period of ten years what he says is of more than usual interest. Five hundred to 600 working oxen and 300 horses are used on his farm. For several years past 5 kilos of molasses have been fed per diem to each animal of 550 to 600 kilos live weight, no distinction being made between stall-fed and working animals. One year 645 steers were fattened during a period of 90 days. The forage was finely chopped and then sprinkled with molasses to be subsequently heated under pressure of two to three atmospheres. The steers received their rations in six meals per diem, the fodder being sprinkled with molasses each time, and after an interval of a few days they declined eating until the molasses was added. The steers kept in an excellent condition when fed with straw, cereal middlings and molasses. The ration for horses was 1.5 kilos to 2 kilos per diem. In this form swine received one kilo to 1.5 of molasses per diem, no allowance being taken of their live weight.

Peanut shell molasses combination.

It is interesting to call attention to the fact that during the first experiments at Toury of horse feeding with peat-molasses, the ration contained 883 grams of digestible albuminoids, which meant 9.8 per cent. of the total nutrients. Experience has shown that in this ration 498 grams of digestible albuminoids are sufficient to meet the requirements of the average emergency. This amount of protein means about 7 per cent. of the total nutritive substances. From this practical experience the astonishing result has been obtained, that the protein may be diminished 385 grams, or 40 per cent., without in any way changing the practical working power of the animal fed. From a common-sense standpoint, it is evident that it is desirable for the horses fed to receive not only an apparently useful element, such as sugar, but also nitrogenous substances in a reasonable proportion, which, all facts considered, would represent a ration suited to the farm-horse in general; for feeding when considered from a general standpoint always means the consideration of many factors, among which not the least important is the neglect or care of the animal's keeper.

M. Lambert, and others, claim to have found in peanut shells the essentials for the emergency. The composition of these is as follows: Water, 7.28 per cent.; ash, 3.39 per cent.; digestible nitrogenous, 1.40 per cent.; indigestible nitrogenous, 4.25 per cent.; amides, 2.57 per cent.; fatty substances, 6.17 per cent.; pentosane, 37.58 per cent.; cellulose, 4.75 per cent.;

unknown substances, 9.86 per cent. This analysis shows that the peanut wastes are poor in digestible nitrogenous substances, but are, on the other hand, rich in fatty substances and pentosane. Even taking these facts into consideration, their nutritive value is very limited. They, however, have the advantage of being readily mixed with molasses, and in more ways than one they appear to offer certain striking practical advantages over peat. When combined with residuum beet molasses, the product has the following composition: Water, 12.61 per cent.; ash, 7.02 per cent.; digestible nitrogenous, 0.95 per cent.; indigestible nitrogenous, 2.35 per cent.; amides, 7.50 per cent.; fatty substances, 1.70 per cent.; sugar, 22.60 per cent.; pentosane, 10.4 per cent.; cellulose, 24.83 per cent.; unknown substances, 10.01 per cent. This combination calls for 45 parts peanut shells and 55 parts slightly diluted molasses, or 51.4 per cent. molasses at 44°. The product costs about 81 cents per 100 lbs.

Efforts were made to give this combination a practical test. The ration per 1000 lbs. live weight consisted of 3.36 lb. crushed oats, 4.90 lbs. peanut shell molasses combination, 6.00 lbs. molasses. The horses fed flourished, and the resulting economy meant 12 cents per diem for each animal fed—in other words 25 per cent., an item not to be overlooked. Unfortunately a serious practical objection followed—it was a pasty compound, not relished by the animals, and in this respect did not prove practical. Notwithstanding this fact, there appear to be many advantages to be derived from the use of this forage, and some claim that it is superior to peat-molasses combinations. From a farmer's standpoint, it is entirely deficient in protein; while from a manufacturer's standpoint, whose main object is to get rid of his residuum molasses under the best possible conditions, when he undertakes to manufacture the fodder himself, peat offers special advantages. However, further efforts have been made to push the peanut shell combination with certain oil cakes, such as the oriental sesame, to which must be added oat flour or crushed wheat, etc. The sesame and peanut-molasses combination has about the following composition: Water, 12.74 per cent.; ash, 8.07 per cent.; digestible nitrogenous, 9.34 per cent.; indigestible nitrogenous, 2.0 per cent.; amides, 5.25 per cent.; fatty substances, 3.66 per cent.; sugar, 2.0 per cent.; pentosane, 6.54 per cent.; cellulose, 15.03 per cent.; unknown substances, 17.43 per cent. It is to be noticed that the laxative effects of the molasses are, in an important measure, done away with by the contrary influence of the sesame. It is claimed that the nutritive value of the combination is high, as, besides its equivalent in sugar, it contains a considerable proportion of fatty constituents, with other hydrocarbons readily assimilated. The final combination for horses, as adopted at Toury, consists of oat flour, peanut shells and molasses; its composition is as follows: Water, 16.69 per cent.; ash, 5.62 per cent.; digestible nitrogenous, 3.20 per cent.; indigestible nitrogenous, 1.80 per cent.; amides, 3.19 per cent.; sugar, 15.98 per cent.; starch, 13.20 per cent.; pentosane, 9.32 per cent.; cellulose, 14.64 per cent.; unknown substances, 10.97 per cent. It is made up of 36 per cent. molasses (44 per cent. sugar), 35 per cent. crushed oats, and 27 per cent. peanut shells, to which must be added the water absorbed during eating. The nutritive value of the compound is self-evident. It is declared by M. Lambert, that of all the combinations thus far proposed, none offer the special advantages of the one just mentioned.

Hay, straw and molasses.

The early experiments with sheep were with 2 lbs. hay per diem and subsequently with 1 lb. of hay and one-quarter pound molasses; the animal remained in an excellent condition. Later experiments show beyond cavil that when oxen were fed with a mixture of molasses and barley straw, or a mixture of straw and oil cake, they could be kept in a good healthy condition during the winter. The maximum limit that should be fed per diem was found to be 8 lbs. per 1000 lbs. live weight. It was claimed that larger amounts could not be assimilated and would therefore be wasted. For milch cows, the molasses was simply added, and there was no decrease in the milk production as is usually the case when changes are made in the regimen. Fed in quantities of 2.2 lbs. per diem, the percentage of fatty substances in the milk was increased. In 16 cows under experiment the fat percentage rose from 3.71 to 3.94, and in another series of experiments upon 60 cows this percentage rose from 2.89 to 3.3 per cent., the quantity of milk in this case increasing by 10 quarts per diem. In another series of the early experiments made with 12 cows in Austria, the quantity of molasses fed was daily increased from one pound to 2¼ pounds. The total molasses fed was about 100 lbs., and as a consequence the volume of milk increased by 35 quarts during the last five days of the experiment. Mention may be made of Ramm's experiments, in which the standard ration of the cows was 10 lbs. hay, 3 lbs. chopped straw, 50 lbs. forage beets, 4 lbs. of flour per 1000 lbs. live weight. Here again the quality and quantity of milk was considerably increased. In Vibrans' experiments the hay and chopped straw fed were sprinkled with molasses and subsequently thoroughly combined; then sprinkled with cotton-seed flour and again mixed. The results obtained were far more satisfactory than had hitherto been realized. The first mentioned experimenter gave to sheep 36 lbs. per 1000 lbs. live weight. With pigs only 4 lbs. per 1000 lbs. live weight could be advantageously fed.

Vibrans has been able to make an excellent fodder, which is very compact and dry, by combining 3 per cent. residuum molasses with 1 per cent. pulverized straw. The straw has an important advantage over peat, as in itself it contains important nourishing properties. The use of beet molesses for cattle-feeding is not new, and in France, as early as 1829, M. J. J. Bernard diluted molasses to 20° B. and combined it with chopped straw and fed it to cattle, horses and sheep.

Molasses and straw combination.

Molasses and straw combinations were at one time very much in vogue. In order to make the mixture the straw had to be reduced to a powder, and it was claimed that it would have all the advantages and none of the disadvantages of the peat-molasses compounds. The apparatus needed is most simple and may be managed by any farmer.

Seidel mixes diluted molasses with chopped straw for growing steers, which have been fed during the first month with 1½ kilos of molasses per head and per diem; then 2 kilos per head and per diem, which means about 4 per cent. of the animal's weight, and he thereby obtained excellent results, the meat being irreproachable in every respect. Working oxen received between November and May 1½ kilos of this residuum per diem. However, in this exceptional case the results obtained with milch cows were not very satisfactory.

If one wishes to mix the residuum with chopped straw or other forages, it is recommended that the product be always diluted, and that atomizers or sprinklers be used for the purpose, which method is becoming very popular. After sprinkling, the mass is turned over and thoroughly mixed. This combination is much liked by cattle in general, who eat the same with avidity.

Of late Wrede proposed that straw be submitted to a regular crushing, which treatment suitably facilitates its power of absorption of molasses. The coefficient of digestibility of straw would be increased by this operation. When it is desired that the diluted molasses be fed at once, certain precautions should be taken, such as great cleanliness of all the mixing appliances, as there are dangers of fermentation which might subsequently affect the animals seriously.

Potato pulp and molasses.

Experience shows that excellent combinations have been made by adding potato pulp to molasses. Maercker submitted this pulp to the action of lime in a large receptacle, subsequently washing it with a jet of water and pressing in a special rolling combination. The product was ultimately dried in special troughs, having spiral agitators. In the proportion of 1 part molasses to 4 parts potato pulp, the molasses is immediately absorbed. The pulp contains only 30 per cent. of dry substances, and is very much improved in this respect by the mixture of molasses containing 85 per cent. dry matter. Furthermore, this combination may be dried in a Buttner-Meyer furnace. Among other interesting experiments may be mentioned those in which the combination consisted of equal proportions of wheat flour and molasses.

Brewers' grains and molasses.

Seidel fed 2 kilos of brewers' grains, combined with molasses, in the proportion of one part molasses and one part grains, to 150 working horses and 10 saddle horses, and he declares they were in far better condition than if they had been fed on oats alone. Only one case of colic was noticed, and this after a time disappeared. Two kilos of this forage took the place of 2 kilos of oats, with a considerable money saving to all interested. The molasses-brewers' grain combination also produced excellent effects upon young cattle, pigs, etc.

The Poppelsdorf (Germany) experiments demonstrate beyond doubt that these molasses combinations constitute an excellent fodder for milch cows. Combinations made up of powdered oil meal and brewer's grains undergo many alterations. The excessive acidity may in a measure be overcome by adding a certain amount of lime, leaving 20 per cent. moisture for the combination. In damp climates it is almost impossible to keep the product in question for any length of time; but when it is to be consumed at once, these transformations have but a secondary importance.

Palm oil and molasses combinations.

In the Hollrung experiments the forage contained 50 per cent. residuum molasses and 50 per cent. so-called palm-nut meal. The composition of the product was as follows: Nitrogenous substances, 11.4 per cent.; raw fatty substances, 3.18 per cent.; non-nitrogenous substances, 44.03 per cent.; cellulose, 17.53 per cent.; ash, 6.3 per cent.; water, 17 per cent. The daily ration was 2.8 lbs. for milch cows, 4.5 lbs. for oxen, 2.2 lbs. for horses, and ¼ lb. for sheep. These experiments were very successful. It was shown that the intestinal canal was kept thoroughly clean, and in no instance was there recorded a case of colic. The palm meal molasses combination has now become a very important industry in Bohemia, and there is an establishment that makes nothing else. Voigt's experiments were with compounds of palm and coco oil meal and molasses, which were fed to 16 omnibus horses, their regular rations being 19 lbs. corn, 9 lbs. hay, 9 lbs. straw, 2.2 lbs. chopped straw. The corn in the ration was reduced to 14.3 lbs., and instead of the 4.7 lbs. there was used an oil meal molasses mixture. The results were so satisfactory that the preparation was fed to 850 horses.

It is important to note that the use of oil meal or substances of any kind that have undergone the slightest organic alteration is a great mistake when a healthy ration is the main object in view, and herein is the difficulty in all these compounds with green molasses and the superiority of liquid molasses. The objection to oil cake and molasses was that its use could not be made general; under certain circumstances its mixing with rations was impossible, hence bran and molasses in equal amounts was found to be better suited for general feeding purposes.

The palm oil and molasses product may be ground to flour, and combined with 80 to 100 parts in weight of heated molasses, at a temperature of 60° to 100° C. This is mixed upon a cemented platform, using wooden shovels for the purpose. The hotter the molasses the more complete will be its combination with every particle of oil cake, and the ultimate product will be so much improved. At first this combination is more or less fluid, but after a time it assumes a dry aspect, and in reality is sufficiently free from moisture to be placed in sacks and shipped almost the same as flour. A man may prepare from two to two and a half tons of this forage in a day.

The workshops of Selwig and Lange, at Brunswick, have delivered to the sugar factory at Schende (Germany) a special and well-arranged mixer, permitting the preparation of 50 tons of this forage per diem. Herewith is the composition, as prepared at two factories:

TWO ANALYSES OF PALM OIL AND MOLASSES COMBINATIONS.

Constituents.	Schwanberg sugar factory.	Alt Jauer sugar factory.
	Per cent.	Per cent.
Moisture	17.7	15.38
Ash	6.13	5.96
Fatty substance	3.18	4.27
Nitrogenous substance	11.39	12.81
Cellulose substance	17.53	12.15
Non-nitrogenous	44.07	49.4

This forage produces the best effects upon the general health of animals to which it is fed. It is not used solely for cows and sheep. Since 1896, an omnibus company, organized in Berlin, has fed 850 horses with this forage. The horses have been in excellent health, and the combination has resulted in considerable profit to the company.

On certain French farms where diffusion pulps had been combined with wheat straw and 2 kilos of oil cake, 3 kilos of molasses were substituted for the latter. The steers continued to fatten, and were in much better condition than in former years. In the case of working oxen, 2 kilos of molasses were used instead of 1.250 grams oil cake, while horses received 1.500 kilos of molasses per diem.

Suitable receptacles for raw molasses and its transportation form difficult problems for the farmer, whereas molasses-forage combinations may be shipped in bags. The first efforts in this direction were those made with palm-oil cake, for the simple reason that it was possible to obtain a combination consisting of 60 per cent. molasses and 40 per cent. oil cake, which was mainly used for milch cow feeding.

Blood molasses combinations. There is another forage to which a great deal of attention has been given of late, and that is a mixture of animal blood with molasses. For many years molasses has been mixed with fresh blood to form a forage for pigs and also for horses and lambs. Blood has a very considerable nutritive value, which has been long since demonstrated by Sanborn. Its principal function consists in forming muscular tissue, and this is made evident by examining its composition, which is, according to Bunge, about as follows:

	Globules, 31.87 per cent.	Serum, 68.13 per cent.
	Per cent.	Per cent.
Water	19.12	62.22
Hemoglobulin and albumin	12.36	4.99
Unknown organic substances	0.24	0.38
Ash	0.15	0.54

According to Misl and Strohmer, the average composition for ten analyses of blood-molasses combinations as now used was: Water, 77.93 per cent.; protein, 20.88 per cent.; unknown organic substances, 0.96 per cent.; ash, 0.82 per cent.

Possibilities of blood-molasses combinations.

When one reflects upon the possibilities of this molasses utilization, appalling facts become apparent. In the ordinary slaughter-houses of most of our popular centres the volume or quantity of blood that remains is something stupendous—as, for example, in Vienna, where it reaches 6,000 tons per annum. If we should combine residuum molasses with this product, we would have at once at our disposal enough forage to feed the majority, if not all, of the live stock of that empire, and there would be very little call for other feeding stuffs.

Molasses acts as antiseptic.

Molasses-blood combinations are always made up of other ingredients, such as bran, oil cake, etc. In these mixtures, molasses, according to Fredericksen and Clausen, prevents the putrefaction of the blood, owing to the presence of a large percentage of sugar. The activity of micro-organisms in this combination is thus paralyzed. Experience appears to show that it is a mistake to add more than 10 per cent. blood to the molasses. It is interesting to note that in order to obviate organic changes entirely one may heat the forage at a temperature of 80° to 100° C., which means to desiccate the product so that it will ultimately contain 15 to 20 per cent. moisture. Without doubt this has an excellent effect, as it obviates the contamination of many diseases, such as tuberculosis. The disinfecting action of molasses was discovered as follows, the present arguments being the outcome of the observations of Stein, at Copenhagen. A servant accidentally upset a certain amount of molasses into a receptacle full of blood. In the desire to make amends for his individual shortcoming he endeavored to procure other blood, but not being successful he admitted the accident. The receptacle which had previously contained the overturned blood was forgotten and put aside, and when examined later it was noticed that the blood had been completely preserved through the intervention of the molasses, and it was in no way altered from its primitive organic condition.

Fresenius has endeavored for a long time, but without success, notwithstanding even the action of micro-organisms, to bring about a putrefaction of a molasses-blood combination, by keeping it in an oven, at a temperature of 37° C., during a long period.

Method of preparing blood-molasses combinations.

Haefke gives the following description of Frederiksen's method for preparing a blood molasses feed. This mode has hitherto been considered a secret. The blood is collected in a receptacle, and in order to prevent its coagulating a small turbine is placed in the midst of the product to keep it in constant motion and to break up any particles that it may contain.

It is then run into a large mixing tank with an agitator having a vertical shaft with horizontal arms. There is added to the blood 25 per cent. of molasses. Subsequent to the mixing a pump forces the mixture to a last compounding appliance, where the porous substance is added, such as bran, etc. This compounding apparatus consists mainly of two rollers moving in opposite directions, so that the paste shall be thoroughly mixed. Finally the forage is dried in what is known as the Otto furnace, used for the drying of distillers' grains. This dryer consists of two compartments or troughs, one over the other, heated by steam, and in each of which there is an agitator consisting of coils through which expanded steam circulates. This heating brings about a sterilization of the combination. From the first trough the forage falls into the second, through which it passes, and ultimately leaves the apparatus entirely dried.

The composition of the blood-molasses combination such as is made at Copenhagen, Berlin, Hamburg, Hanover, Milan, etc., is as follows:

	Per cent.
Water	9.40
Amides	3.56
Albumin (nitrogen × 6.25) =	24.19[1]
Fatty substances	3.15
Ash	7.6
Cellulose	8.6
Non-nitrogenous elements	43.5

Varied absorbents may be used.

Besides bran the blood may be absorbed by brewers' grains, dried cossettes, etc., and subsequently mixed in the desired proportions with molasses. Under these conditions it is readily handled and possesses all the qualities looked for in molasses mixtures. The composition of these various combinations is as follows:

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[1] Ninety-six per cent. is digestible.

ANALYSES OF THREE BLOOD-MOLASSES COMBINATIONS.

Constituents.	Blood + wheat bran + molasses.	Bran + blood + brewers' grains + molasses.	Blood + dried cossettes + molasses.
	Per cent.	Per cent.	Per cent.
Water	7.33	8.51	8.53
Nitrogenous substances	24.62	25.00	29.55
Non-nitrogenous substances	3.32	2.88	3.51
Fatty substances	1.04	0.14	0.22
Sugar	7.50	12.90	16.69
Non-nitrogenous not specified	42.20	35.20	30.69
Cellulose	7.02	9.77	6.24
Ash	6.10	5.35	4.44
Sand	0.87	0.25	0.13

In the four analyses given it is to be noticed that there is a considerable percentage of albuminoids and sugar, all of which are easily digested. Notwithstanding the sterilization of the compound, the digestibility of the albumen of the blood remains higher than the digestibility of vegetable albumen. Maercker found that 95.9 per cent. of this albumen could be assimilated.

Elimination of fibrin.

Jolles eliminated the fibrin of the blood and then submitted it to a centrifugal action in order to separate the serum. The globule-like paste thus obtained is four times richer in nitrogenous substances than was the fresh blood, and has greater keeping qualities, which may be still further increased by adding 10 per cent. of molasses. It has been suggested that this compound shall be absorbed by suitable porous feeds, and then it need not be submitted to a desiccation in order to give it excellent keeping qualities. It consists of concentrated forage of great nutritive value and possessing exceptional digestibility, which is admirably suited for cavalry purposes, Already 24 regiments of Germany have adopted it. Its composition varies with the manner in which it is prepared. Herewith are two analyses of interest:

TWO ANALYSES OF BLOOD-MOLASSES COMBINATIONS (FIBRIN ELIMINATED).

	Per cent.	Per cent.
Water	9.93	7.40
Nitrogenous substances	32.69	44.66
Non-nitrogenous substances	1.85	1.68
Fatty substances	0.68	0.82
Sugar	5.70	7.90
Cellulose	9.00	6.67
Ash	3.82	5.21
Sand	0.11	0.10
Non-nitrogenous not specified	36.22	25.56
Total	100.00	100.00

Feeding horses with blood molasses.

The health of horses under this feeding appears to be excellent and the digestive energy is in no way impaired. Certain authorities declare that for horses the product should be given gradually, in order that the animals may become accustomed to it little by little.

It is impossible to feed protein to excess and decrease the fatty substances. It is, furthermore, impossible to substitute more than one-half of the oats ration by this feed. In many cases 2 kilos are given per diem, and the oats ration is reduced from 6 kilos to 3 kilos. By this arrangement good results are obtained, and after a year's feeding the health of the animals is all that can be desired. A saving in money always follows its use. Some authorities declare that the milk production is increased 5 per cent. per diem. Experience seems to show that it is possible in the case of milch cows to substitute for certain oil meals this molasses-blood forage combination.

Feeding cows.

Lienthal has obtained very favorable results in feeding cows. He estimates that the profits from this feeding may be put down at 40 pfennigs [10 cents] per head and per diem. The results obtained with pigs were less satisfactory.

Feeding pigs.

This, according to Maercker, seems paradoxical, as this forage would appear to be easily assimilated and adapted to the intestinal digestion of pigs.

These results are absolutely in contradiction with those obtained in America with blood-feed combinations, and Maercker believes it is mainly to the absorbing material used that we must look for the difficulty that has rendered it objectionable for this special purpose. On the other hand instances may be given in Austria of feeding over 2,000 pigs for a year with blood-molasses, and an enormous number of their young were nourished during this interval.

Feeding to animals in general.

Results published relating to blood-molasses combination all show that excellent effects may be expected from its use. It may safely be said that chickens, geese, ducks, oxen, etc., will relish it. In the case of steers the quality of the meat is materially improved.

Ramm and Mintrop have fed 6 to 8 kilos of this product per diem without the slightest complications. The general secretions were favorable, showing that the assimilation in every respect had been satisfactory.

Feeding to horses.

There are many German authorities to show that these combinations have given excellent results in cases where certain muscular force is needed, such as for horses; and in most instances there have been considerable money savings, owing to the substitution of this product for oats and corn.

Extension given to blood-molasses feeding.

Without doubt this combination has a future, and some factories that are actually in existence in Continental Europe which utilize this beet-sugar molasses in combination with blood cannot meet the demand for the product. The cost of this combination cannot be determined with great accuracy, for the simple reason that it depends upon so many factors. Under all circumstances one should consider the market value of the concentrates used and make allowances for the facility of obtaining it in the quantities needed.

Money value.

When molasses is to be used the fact must not be overlooked that allowance must be made for its money cost. In order to establish the price that one can reasonably pay for a forage-molasses combination, one allows for the sugar percentage upon the accepted basis of 50 per cent. of sugar in the residuum. The price of the mixture may be then calculated without trouble. The ration should contain sufficient fatty and albuminoid substances in order to make up for what is lacking in the molasses, for in this there will always be found the requisite non-nitrogenous substances.

General rations.

The quantity of the ration that may be fed without danger to different animals is as follows:

Growing steers	4 to 6 kilos per 1000 kilos live weight.
Working oxen	2 to 3 kilos per 1000 kilos live weight.
Milch cows	1 to 1¼ kilos to animals of an average weight.
Growing pigs	½ kilo to animals of an average weight.
Growing sheep	200 grams to animals of an average weight.
Superior sheep	100 grams to animals of an average weight.
Horses	1 kilo to animals of an average weight.

These figures cannot be taken as absolute, as they vary with the characteristics of the animal being fed, and a certain care is always required to accustom the animals to it.

Experience shows that the best results are obtained by feeding one-fourth of the ultimate ration per diem, and increasing the amount week by week. Under these circumstances all the objectionable features of this forage are overcome.

Preparing the blood-molasses fodder on the farm.

The ideal utilization of this molasses-blood combination would be for the farmer to compound his own mixtures as the occasion might demand, using a special machine not costing much, which could be carried from place to place as required.

The Shraeder apparatus in a measure combines these requisites. The mixture is heated, either by steam circulating directly beneath the dryer, or preferably directly over the fire, taking the precaution to have a double bottom in which hot water circulates. The blood, forage, and molasses, are fed to the apparatus by a rotating distributor whose working is regular, and which may be arranged so as to meet any demand. The molasses and the feed are then mixed in a cylinder, in which there are special agitators.

By the use of an apparatus of this kind one can overcome in a measure the losses during keeping and thus economize an amount of money that will more than compensate for the cost of the machine and do away with the profits and demands of the third party.

Difficulties in keeping.

The keeping of this special product has offered some difficulty, as the sugar percentage of most of these compounds is such as to cause rapid alteration owing to fermentation. The bacteria formed exert their influence, causing diarrhœa among the animals. It has already been noticed in Germany that these transformations of the blood-molasses may be so intensive that the mass becomes heated, and spontaneous combustion follows.

Experience shows that it is desirable to take certain precautionary measures in order to overcome this difficulty. Under all circumstances the product should never be placed in bags before it is completely dry. Furthermore, it should never be kept in any warehouse where wood is stored. The storehouse should be built entirely of stone, and the product itself should not be piled up too high.

Vaury wheat flour molasses combination.

The Vaury preparation having been so generally accepted in France, it is interesting to follow up the combination in some detail. The inventor says that his effort was to combine a product that could be carried without difficulty and would not possess any of the objectionable features of the molasses-peat combination; for why introduce into the stomach a mass of inert substances that are not assimilated? Animals under this regime are obliged to waste their powers in masticating a substance that is worthless, so far as their general health is concerned. Whatever may be the worth of the arguments against peat combinations, they continue to be in vogue. The object Vaury had in view was to use other constituents, offering all the advantages and none of the disadvantages of the previous combinations. Wheat flour of a superior quality was the basis adopted. The thorough mixing was one of the essentials for success, and this was followed by a limited fermentation and baking, the result being bread, in the general acceptance of the expression, in which all the ingredients are assimilated. There are used 100 parts of wheat flour and about 70 parts molasses. This is mixed and kneaded so as to form a paste, as is done in bread-making. To this paste or dough should be added a suitable ferment. It is run through special mechanical appliances in which the thickness, etc., of a standard dimension are obtained. These cakes are baked in an oven and subsequently broken into pieces. The bread-molasses thus obtained may be fed in a dry condition to horses, or in a semi-moist state to animals in general. Experiments in general thus far made appear to show that this combination is entirely digestible. It is claimed that there are no dangers of colics through its use, that the desired fattening results are realized, etc. It is said that the Vaury bread-molasses combination has the following composition: Nitrogenous substances, 10 to 12 per cent.; hydrocarbons, 50 to 60 per cent., of which 25 to 50 per cent. are saccharine substances, 12 to 15 per cent. moisture, and 10 to 12 per cent. mineral substances. All facts considered, the molasses combination, just described, deserves more than a passing consideration.

Solid molasses is made by combining the residuum with sawdust; it may be readily carried in that condition. The mixing consists in using 100 parts molasses for 15 to 20 parts sawdust, and evaporating during constant agitation, lasting for over an hour. The final product is brown in appearance, not sticky, and has the characteristic odor of molasses. The sweet water of exosmosis may be treated in the same manner. The sawdust does not prevent fermentation, nor is it in the way when the residuum is to be incinerated. The apparatus used for this purpose may be employed for the preparation of molasses fodders, etc.

Requisite keeping qualities of molasses.

Molasses, as it leaves the beet-sugar factory, seldom contains more than 22 per cent. water and may be kept for a considerable period; but when this percentage reaches even 25, alterations are to be dreaded. In the preparations of molasses fodders, it is always desirable to concentrate as much as possible and not to dilute the product.

According to observations at the German agricultural stations, those forages belonging to the same class as molasses should not contain more than 20 per cent. water, and not over 25 per cent. for peat molasses combination, as the higher this moisture percentage is, the greater are the chances of decomposition during its keeping.

These fermentations are always accompanied by considerable sugar losses. It may be mentioned that after a year's keeping almost all the sugar has disappeared, which is often the cause of considerable litigation between the seller and the purchaser, the latter never finding an equivalent for his money; but manufacturers of this molasses forage combination declare that the disappearance of the sugar does not necessarily signify that the forage has lost its nutritive value.

The money value of the nitrogenous substances of molasses is also a factor which has a pecuniary import not yet settled in practice. Furthermore, it is important to add that the analyses of molasses forages are very difficult operations.

According to Gormermann, it is mainly in oil cake feeds that rapid alterations are to be found. The acids contained in different substances with which the molasses is mixed favor all sorts of fermentations. The acid in distillers' and brewers' slops is lactic acid. In oil cake it is oleic acid, while in peat there is a long series of acids, the principal one of which is humic acid.

As regards brewers' slops, it would be useless to attempt to neutralize it in order to increase its keeping qualities, as it is precisely this acidity that is so much relished by the animals to which it is fed. Oil cake has the advantage that the oleic acid which always brings about digestive complications is neutralized by the addition of lime and molasses. It must be noted that this addition of lime does not entirely do away with the action of certain micro-organisms of oil cake upon the fatty substances which they contain. The existing acids are neutralized, but if one wishes to do away entirely with these micro-organic transformations it is essential not to attempt the keeping of this special forage.

Dishonest dealings in molasses.

Molasses forages in Europe have a disadvantage of being expensive, on account of the industry, in many cases, being in the hands of a very few, who thus make their own prices. In order to avoid the frauds committed by the middle-man, it is found preferable for the purchaser, who is the user, to deal directly with the manufacturer, whereby one is more sure of what is being bought. The appearance of this fodder, or even its odor, does not enable one to distinguish within what limits organic transformations have taken place, and if one is dependent on the dealer it is recommended to have the product properly analyzed by a competent chemist. Both analytical and microscopical analyses should be made. Unfortunately the existing fraud is very general. For example the agricultural station of Halle (Germany) found one-third of the samples examined for a period of one year misleading, and over 8 per cent. absolutely fraudulent.

Keeping qualities of peat molasses.

Peat-molasses mixtures have considerable keeping qualities, as peat in itself does not favor the development of micro-organisms. Experience appears to show that if these fodders are kept in some warm place, they will lose 50 per cent. of their moisture.

It is claimed that the losses during the keeping of peat-molasses combinations, as asserted by some, are the outcome of faulty observations, as this forage contains in reality very little peat, and furthermore the slight acidity of the product should be neutralized by the normal alkalinity of the molasses. The objection found to this is that the molasses, which is alkaline, should become spontaneously acid owing to the action of micro-organisms.

Experience shows that the general molasses combinations have not the keeping powers they should have, and after less than a year's storage the sugar loss is over 40 per cent., not including the invert sugar formed. In Germany other experiments have shown that this loss means 60 per cent. for the protein and 50 per cent. for the sugar. The leading authorities admit that these losses may be attributed to the combined action of moisture and micro-organisms, hence the reason why such products should undergo a drying process before being placed in bags.

Keeping molasses combinations in general.

Molasses may be kept on the farm in a very simple way. Formerly cemented silos were used, but now holes are dug in a close clay soil and the molasses poured in. The bottom is clay, and against the sides are placed boards so as to prevent the dirt from falling into the mass. The objection to cemented silos is that the residuum soon acts on the cement. Mr. Guttmann employs molasses mainly to force the consumption of the general wastes of the farm, and uses very little oil meal.

Molasses Forage Made at the Factory.

Attention is called to cakes of molasses made at the Attigny sugar factory, France. The cakes in question have about the following dimensions: 9 inches in length, 4 inches in width, and two inches thick, and weighed 650 to 700 grams (an average of about 1¼ lbs.). They are obtained by mixing 50 lbs. molasses (45 per cent. sugar), with 25 lbs. flour and 25 lbs. chopped straw. The mass is submitted to a thorough mixing and kneading and is then compressed in regular shapes, in very much the same apparatus as is used for bricks, and the cakes obtained are then baked. The temperature of the oven should not be more than 130 to 135° C. (266 to 275° F.); as otherwise there would be danger of carbonization. The baking lasts 1¼ hours, during which period about 10 per cent. of the moisture is eliminated; 100 lbs. of the product will give 90 lbs. of this brick-shaped food. The cakes should be kept in some dry place. In practice it has been found that there are many advantages in having the forage in cakes of a known size and composition, and when the conditions of feeding special live stock are determined, it is sufficient to give to the feeder full instructions as to the weight of the product to be used for each ration. As the straw used comes from the farm connected with the factory, this means an economy in the combination. The appliances necessary for the manufacture of the molasses fodder under consideration are most simple. The first is a mechanical kneading device for mixing the flour, etc. It is emptied by simply tipping the mixer forward when the operation is finished. To this is a vertical mixer not unlike the machine used for residuum beet cossette pressing; it has a vertical shaft with projecting axis arranged as a spiral. In the cake-making apparatus two bricks are made at the same time, and the movable oven is about six feet in length. The arrangement at the factory in question is only temporary. Its practical working is as follows: Into the mechanical kneader are introduced 50 lbs. molasses and 25 lbs. of flour; after twenty minutes' mixing and kneading the mass is in a homogeneous condition and is emptied over 25 lbs. of chopped straw at the bottom of a square-shaped box placed in the ground, its dimensions depending upon the volume of the product used. The first mixing of the molasses compound and straw is done in the receptacle in question with a shovel or pitchfork, and the combination is then thrown into the vertical mixer, from which it enters the compressor, and is then cooked in the oven. In cases where this molasses fodder is to be consumed at once it is not compressed, but is simply emptied into small wagons running on narrow-gauge tracks to the stable. At the factory under consideration, about 4½ lbs. of the product are fed to either horses or oxen. The combination in question contains about 20 per cent. moisture, and is consequently dryer than the original molasses. Upon general principles one might conclude that the removal of additional molasses was unnecessary; but this idea is a mistake, for the moisture contained in the products added might be the cause of fermentation unless the drying were continued; and furthermore, both the straw and the flour bring with them certain micro-organisms which sooner or later exert their destructive influence.

Molasses combination made at the farm.

The question of the possibility of manufacturing the molasses combinations upon the farm has led to a series of very elaborate investigations in the laboratory of the sugar manufacturers' syndicate of France. The starting point was the Vaury molasses cakes containing 50 per cent. molasses and having the following composition: 25 to 28 per cent. saccharine substances, 45 to 48 per cent. hydrocarbons, 9 to 12 per cent. nitrogenous substances and 1 per cent. fatty substances. Just what ingredients are used is unknown. Its cost, $1.36 per 100 lbs., is and has been one of the objections to its general use. The first object in view is to utilize any waste material that may be found in the barn and to select a substance that may be used to combine with molasses, so as to form a solid, nearly dry mass which may be readily carried from place to place as it may be called for. In the first series of experiments, the drying of the combinations was done in an oven. First combination: 100 parts wheat flour, 2 parts yeast and 50 parts water, well mixed with 100 parts molasses at 38° to 39° Bé. and 80 parts of pulverized oil cake. It is baked in an oven and becomes nearly solid. Second combination: 30 parts wheat flour with the requisite water and yeast, 100 molasses, 80 pulverized oil cake. The resulting cake can be readily carried. Third experiment: 25 wheat flour with the requisite water and yeast ferment, 100 molasses, 100 to 110 pulverized oil cake. It was concluded that the percentage of wheat flour was not sufficient. Fourth experiment: 30 wheat flour with water and the requisite ferment, combined with 100 molasses, etc. In the other series of experiments, the preparations were heated in a furnace up to the temperature of 95° to 100°. Corn flour was found preferable to wheat flour the combination used being 100 corn flour, 100 molasses and the remainder bran. After a thorough mixing, the ration was cooked in a furnace for from 9 to 10 hours. It was further considered, in a series of practical experiments, what forage was the most suitable to be combined with the molasses, and what was the most desirable duration of the period of heating or cooking in the furnace.

Simple appliances for mixing.

In Germany, special molasses mixing appliances are sold for $60, their capacity being nearly 500 lbs. per hour. This apparatus is about 6 feet long, 12 inches wide and 16 inches deep. The mixing shaft has a velocity corresponding to 35 revolutions per minute. An apparatus for mixing 3 tons of the fodder per hour may be had for $150. In this case the revolving shaft turns with a velocity of about 150 revolutions per minute. When the molasses combination is finished, it is emptied on a cemented floor and allowed to cool. Certain precautionary measures are to be taken during the mixing, for there is danger of fire; but this danger may be obviated by having a thickness of only 18 inches of the product during the mixing in the special apparatus. After 24 hours' cooling the molasses combination may be put up in bags and after several days additional cooling, it may be stored in warehouses just as sugar is.

Molasses may be rendered liquid by heating at 70° to 75° R. The concentrate is added, and then thoroughly mixed until cooling. Experience shows that the mixing tanks should be made of wood, rather than iron, and be rather shallow. The cost of this operation is very slight, as one man can prepare fully two and a half tons of this forage per diem. A mixing appliance of the Werner and Pfleiderer system, containing 400 liters, may produce 5 tons per diem. For concentrates, one may use to advantage bran, dried malt, dried brewers' waste, etc. The best proportion for this mixing is one part of each.

The resulting forage will be all that one can desire, having excellent keeping qualities, and not soiling the fingers when touched; it has, moreover, a fine appearance, etc.

The farmer has every advantage in preparing his own combinations, as this always means considerable money saving. Furthermore, he has a certain assurance that the product he obtains is of the quality anticipated. In order to conduct this mixing operation to advantage he can use the waste around his barn, or if he has to purchase outside, he should stipulate that the material in question shall be at a comparatively low rate.

Herewith are several German analyses. These compositions, taken as a whole, vary with the concentrate used.

ANALYSES OF VARIOUS MOLASSES RATIONS.

CONSTITUENTS.	Palm oil meal + molasses.		Corn germ + molasses.			Cocoanut cake + molasses.	Cocoanut wastes + molasses.	Bran + molasses.
	I.	II.	I.	II.	III.			
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	16.93	19.74	14.68	21.00	17.40	20.85	14.10	16.50
Nitrogenous substances.	12.93	12.50	15.37	14.56	14.02	15.25	10.99	11.31
Fatty substances	1.64	2.12	3.79	3.79	5.78	2.19	1.72	4.67
Sugar	26.60	27.93	26.51	25.30	26.00	29.43	24.28	24.20
Non-nitrogenous substances	26.14	15.36	29.45	26.70	26.70	20.47	32.12	32.20
Cellulose	7.80	16.20	3.33	2.58	4.32	3.07	7.05	5.52
Ash	7.85	6.12	6.82	6.07	5.78	8.28	9.74	5.60
Sand	0.11	0.03	0.02	.....	......	0.46	....	....
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Albumin	7.25	7.73	10.37					

Feeding all the molasses from a given area of land.

Maercker has discussed the question of whether a farmer should feed molasses to his cattle rather than the beets from which the residuum was obtained. He says, we may suppose that, to every 2½ hectares (6¼ acres) there is one head of cattle to be fed with molasses. Each 2½ hectares is submitted to a rotation demanding its cultivation only after four years, and the beets resulting from the same correspond to

40 tons to the hectare (16 tons to the acre). If we assume that from the beets at the factory there is obtained 2.5 per cent. molasses, the said 2.5 hectares, admitting only ¼ is cultivated in beets, will furnish 625 kilos of molasses, which each animal will have at its disposal. This corresponds to 1.7 kilos of molasses per diem during the entire year, which may be readily consumed.

But it must be noticed that one does not always obtain 40 tons to the hectare, and furthermore, that the four-years' rotation is not always practicable. It frequently happens that one cow is fed from two hectares. Under these circumstances the farmer would have at his disposal only 500 kilos of molasses per annum, meaning an allowance of only 1.250 kilos per head and per diem.

However, from what has just been said, it is evident that only under exceptional circumstances one is unable to utilize all the molasses that results from regular farming; that is furnishing the beets to the factory and taking in return residuum, pulps and molasses.

Various uses of molasses.

Efforts have been made during recent years to use this residuum for the preparation of certain chemical combinations. Numerous modes have for many years been introduced for the working of molasses in sugar factories, but have not given the results hoped for.

Various means have been resorted to with a view of increasing the consumption of sugar and molasses. Among these may be mentioned molasses soap; a special introduction for dyeing; also the idea proposed by Vincent, for the manufacture of ammonium chlorid and methyl chlorid; the object in view having been to create an excessively low temperature. The methods of Franck and Nycander for the production of ferments may also be mentioned, and those of Schering for the manufacture of levulose.

It may seem astonishing, but the facts prove that the only molasses utilization that has great practical value, when allowing for its low selling price, is as a feed. This has not received the attention from the agricultural authorities that it justly deserves.

Molasses for alcohol manufacture.

The utilization of molasses for alcohol manufacture is necessarily dependent generally upon the market prices of this product, and as there are considerable fluctuations, the industry itself has many elements to contend with. As an example, during many years in France, special advantages were given to molasses distillers, but in 1902 this legislation was changed and the residuum can now no longer be profitably used for that purpose. This would seem to be a great injustice to individuals who have placed their money in an investment which was supposed to have been backed up by government security. The alcohol-molasses industry in France for the time being has become a question of the past.

In this respect, however, it is interesting to note that it is within the power of capitalists to overcome this difficulty by adding appliances for working up sugar beets to their existing distilleries; but when one considers that the residuum of molasses represents only three and a half per cent. of the raw material sliced, it becomes evident that an establishment of this kind would mean an enormous money outlay.

Many of the existing distilleries can handle the molasses residuum from a plant working 1000 tons of sugar beets per diem. A distillery that could work up the mash from such a bulk of fermented beets would handle several hundred tons of roots in the 24 hours, and the cost of the diffusers and the other necessary appliances would certainly not amount to less than $100,000.

For many years the molasses-distillers' waste has been utilized for the manufacture of potash, soda and potassic chlorid. It has also been used for feeding purposes, and as a fertilizer.

Molasses permits the utilization of slightly mildewed or tainted feeds.

The use of molasses permits the utilization of certain feeds that have undergone more or less transformation during their keeping. For example, hay that was slightly tainted was eaten with avidity when combined with 2.2 lbs. molasses diluted in 3.6 lbs. warm water and oat straw, which stood for 24 hours in order to undergo a partial fermentation. With this feed there was an increase of weight. The explanation is that the molasses is possessed of certain disinfecting properties.

Molasses as a fertilizer.

Considered only from a theoretical standpoint, molasses is a most excellent means for returning to the soil the plant foods that have been taken away during cultivation of the crop of beets without resorting to the use of expensive manures in order to retain the fertility. Without entering into the various beneficial results that must necessarily follow from this practice, it suffices to say that it stands to reason that if certain mineral substances have been absorbed by the beet during its development, these, if returned, will maintain the continued fertility of the soil, which maintenance would otherwise have been impossible, and the benefits derived become even greater when defecation scums form part of the fertilizing mixture.

However, molasses should never be utilized for fertilizing in its green state, for many of its elements that are worthless for this purpose may render great service in other directions, such as cattle feeding, etc. For the farmer, its money equivalent as a fertilizer must not be overlooked. Unfortunately, however, in the United States the problem of returning the plant food to the soil has been, up to the present, too frequently neglected.

If one makes allowance for the fact that molasses contains, on an average, 1.5 per cent. of nitrogen, and 5 to 6 per cent. of oxid of potassium, and that in the excrements of animals fed upon this product may be found 1 per cent. of nitrogen with 5 per cent. of oxid of potassium, 0.03 per cent. to 0.06 per cent. phosphoric acid, 0.3 per cent. to 0.5 per cent. lime, and about 50 per cent. non-nitrogenous substances, one may conclude that molasses, as a forage, has a greater commercial and rural value than is generally supposed, for the simple reason that to its nourishing value must be added its subsequent use as a manure. Nearly all the foods that plants need are found in the droppings of the animals fed.

Sugar in the animal economy may play an important role, mainly in the formation of fat. Consequently it is of greater advantage to allow these hydro-carbons to pass through the animal's body, than it would be to resort to any preliminary effort of its use as a fertilizer, for the simple reason that the mineral elements always pass through the body of the animal without undergoing chemical changes.

In Germany there are produced 400,000 tons of molasses that contain 5,200 tons of nitrogen, corresponding to 28,000 tons of

Chilien saltpetre. Furthermore, this product contains 28,000 tons of potassium oxid. It necessarily follows that if all the molasses were utilized, farmers would have at their disposal an excellent fertilizing material of the value of $1,000,000. In Germany it was recommended that, in consideration of the low selling price of molasses, the product be practically used as a fertilizer, but this idea was very illogical, as it would be throwing away without any possible profit the money that might be derived from the sugar contained in this residuum, to say nothing of the non-nitrogenous substances to be found in it.

By the use of molasses as a forage the farmer returns all the salts that had been previously taken from the soil, which in other words means all the plant foods that have been extracted by the plant during its growth. Furthermore, there is another advantage derived from this molasses feeding, which is that the money profits derived from the same are generally greater than would have been realized if the residuum were employed for the extraction of sugar.

Analysis of molasses feeds. The Association of Austrian Chemists, during 1901, made the following resolutions: That the molasses forage combinations should be thoroughly mixed, and that the precaution be taken to constantly bring to the top the lower strata of the feeds, as it is there that the molasses always settles. An average sample of 500 grams should be dried at 100° C. and afterwards thoroughly pulverized. Without a previous understanding, this sample should be used for the analysis. The desiccation is done in a small tared receptacle having a suitable stopper hermetically closing the same.

The total nitrogen is estimated by the Kjeldahl method. To 1 gram of this substance with mercury add 30 cc. concentrated sulphuric acid. This acid is used in excess on account of the sulphurous acid liberated.

The nitrogen of the albuminoids is determined upon 1 gram of the substance sprinkled with 100 cc. of water heated to boiling point, 25 cc. of a 6 per cent. solution of copper sulphate and 25 cc. of a 12.5 per cent. caustic soda. The addition of the soda is arranged so as not to precipitate all the copper. This precipitate is rapidly deposited and is filtered, and then washed with water until all sulphate reaction disappears in the filtrate under the action of barium chlorid. It is important to mention in the analysis what method has been adopted for the estimation, and furthermore to state whether the gastric juice of a pig or commercial pepsin has been employed. First of all the molasses should be removed, and five grams of the pulverized feed are washed in 100 cc. of cold water. This water should be added drop by drop, using asbestos as a filtering surface, and then following by an ether extraction.

The sugar estimation is made by the usual method of polarization.

Other non-nitrogenous extractible substances are determined by subtracting from 100 the water, fatty substances, sugar, cellulose, ash and nitrogenous substances multiplied by 6.25.

The cellulose is determined, according to Weender, with 3 grams of sulphuric acid and caustic potash.

The ash is estimated upon 10 grams in a porcelain capsule heated in a special muffle furnace, such as is used in sugar factories.

The molasses percentage is estimated by assuming that the sample polarizes 50. The nitrogenous substances, estimated by using the factor 6.25, should be shown upon the analysis bulletin, and never as raw protein.

The nitrogen of albuminoids, determined according to Stutter, multiplied by 6.25, is known as an albuminoid combination. The nitrogenous substances last found are called amide acids.

The difference between non-assimilated nitrogen multiplied by 6.25 and the albuminoid combinations is called assimilated albuminoid substance.

It is recommended as far as possible to make a thorough microscopic examination of the absorbing substances used. It is desirable, when examining peat molasses feeds, not to estimate the nitrogen in all its combinations, but simply to mention the total nitrogen that it contains.

The Müller method unfortunately can be applied only to fresh combinations. Twenty-five grams of the forage are constantly stirred up with 250 grams of water. One hundred cc. of this solution are treated by 15 to 20 mgr. of tannin, 10 cc. of subacetate of lead, 10 cc. of a 5 per cent. solution of alum, and a very small quantity of hydrated alumina. This is mixed, filtered and polarized. The molasses added to the forage is supposed to contain 48 per cent. of sugar. To determine the fatty substances, the forage is heated in an oven at 100° C. for three hours; it is then reduced to a powder, two grams of which are weighed in a porcelain capsule, and subsequently placed under an air-exhausting apparatus. The molasses is extracted by cold water, the remaining product dried, and submitted to the dissolving power of ether for 15 hours. Under these circumstances there is no saponification of the fatty substances. The details of the operations that follow it is unnecessary to describe.

The fact is that the whole question of molasses fodder analysis has been widely discussed, so much so that a special congress of the German experiment stations was held some years since, and they centered their attention upon the Neubauer method. It is declared that this special forage has but little if any influence on polarized light, and if this molasses combination had any polarizing power it would be necessary to establish special compensating factors for each combination under consideration.

As regards the invert sugar that is formed during keeping and is mainly due to the influence of high temperature, it becomes important to polarize the solution after inversion in order to form some exact idea of the sugar percentage. The polarization gives exact results only for certain forages.

According to Emmerling, in order to estimate the nutritive value of a forage made with molasses, one should take ⅛ of the nutritive value of sugar as the nutritive value of nitrogenous non-albuminous substances, of the molasses that are contained in quantities corresponding to eight times less than the sugar and having the same nutritive equivalent as carbohydrates. It is important to estimate the sugar, the fatty substances and the protein. The data obtained is multiplied by the nutritive value of each of these, allowing for the amids of molasses the same equivalent as sugar, and it is upon this basis that one should compensate for any error that might be made and thereby bring about a certain harmony between purchaser and buyer.

PART FIFTH.

Feeding with Sugar.

Preliminary remarks.

WHAT becomes of sugar formed in the liver and carried to all parts of the body by the blood? What is its role?

Sugar, as its composition shows, contains carbon, oxygen and hydrogen. The carbon throws out in burning, or oxidizing, carbonic acid, water and heat, which may be transformed into work and energy. It is concluded from this that sugar produces at least a portion of the animal heat, and recent experiments show beyond cavil, that we must also look to the same material for the muscular energy or work.

It is to Mr. Chauveau that the credit is justly due for the entire investigations upon this most important subject, as before his time the theories advanced were certainly most erroneous.

Chauveau's theory.

A celebrated authority such as Claude Bernard enunciated the theory that sugar disappeared in the lungs. As early as 1856 Chauveau showed that there were traces of sugar in the entire arterial circulation which gradually disappeared in producing heat. He enunciated his ideas about as follows:

"Energy devoted to the production of work always means muscular energy, and in all cases has for its principal starting point the combustion of glycogen, with which the tissues of the organs are impregnated. Blood becomes poorer in glucose, during its general capillary circulation, and mainly in the muscular tissues."

Chauveau has shown that there existed a relation between muscular energy, glycogen production and the destruction of sugar in the blood. These investigations were mainly centered upon horses, showing the exchange that took place in the blood passing through muscles at rest and during work. As an example the muscles used during mastication and the glands secreting saliva were watched during this study. The law, which was the outcome of this experiment, was based upon the influence of the work of an organ of the body upon organic combustion and also upon the sugar consumed. Chauveau further says:

"The work accomplished by the organs during their physiological activity, indicates that the amount of sugar that disappears during rest is less than during work. It is proportional to the combustion, which is the natural outcome of the working of the organs proper."

An example will give a general idea of the contrast between sugar destruction in the blood, during rest and during work. Blood passing through a special muscle of a horse's mouth during a given time, and while at rest, viz.: when it is not eating, will throw out an amount of carbonic acid corresponding to 20.4. While eating, the amount of carbonic acid thrown off was 69.55. In other words, during the muscular activity of simple mastication the amount of carbonic acid evolved is increased to 69.55 during work, that is, this activity alone demands a consumption in the muscle of over three times that which is necessary during rest.

If one estimates the amount of glucose that disappears in the blood that passes through a muscle during rest and during work, as based upon the experiments of Chauveau and Kauffmann, there is a glucose combustion of 0.12 grams in the first case, and 0.41 grams during work. We may conclude from this that the blood passing through a muscle absorbs during its activity more than three times the amount of sugar that is consumed during rest. From this we may further conclude there is a certain correlation existing between the loss of sugar in the blood and in the increased combustion during the physiological activity of the muscle. Such being the case, there is apparently no doubt that sugar is a direct factor in the question of muscular activity, and this has been the starting point for the re-organization of the daily rations allowed, not only to soldiers, but to horses, in nearly all of the European armies.

Practical tests upon men.

Examples almost without limit can be given of tests upon two regiments of soldiers, one mounted and the other unmounted, one consuming sugar and the other without sugar, where the amount of work accomplished was certainly in favor of the sugar ration. Much remains to be done in this special direction, but what has been accomplished is certainly a hint as to future possibilities.

Schönberg has noticed the excellent results that may be derived from sugar feeding, and which were based upon a very simple experiment of giving only 30 grams of supplementary sugar to a gang of workmen; this alone was sufficient to prolong their efforts for several hours without any perceptible fatigue.

Advantages to the breeder.

Such being the case, it stands to reason that the breeder has every advantage in introducing a reasonable amount of sugar into the daily rations of the animals under his care, when the opportunity presents itself.

It is interesting to note that investigations relative to the influence of sugar upon muscular energy have become extremely popular during the last few years. It is not long since that the theory obtained that nitrogenous substances were always responsible for muscular activity. Hence the animals, from whom considerable work was demanded, were fed upon very narrow rations.

Feeding of sugar to cattle in the early part of last century.

Sugar for cattle feeding commenced in the fifties in Continental Europe, but as we have before pointed out, the utilization of sugar for this purpose goes back to the early part of the last century, and, notwithstanding constant agitation arguing in favor of its importance, it is only within comparatively recent years that the practice has made any important progress. Strange as it may seem, as early as 1800 the British market was almost glutted with sugar and it was during the years that followed, that several interesting pamphlets were written upon sugar in cattle feeding. The arguments then advanced are true at the present time, and there is now a threatened overproduction. The sugar consumption was very small a hundred years ago, hence the several sugar islands could more than meet the demand. The situation in 1901 has changed; sugar has become almost a household necessity, and the beet sugar and cane sugar, in their efforts to meet the demand, have thrown upon the market a volume of this commodity, which has resulted in a constant fall in price, giving a just cause of alarm to all interested. Efforts are being made in Continental Europe to popularize and increase the demand for sugar; new theories have been introduced showing that sugar means strength, which is in direct contradiction to the views entertained not many years since by most of the medical authorities.

Early arguments for feeding sugar were, that one shilling's worth of sugar will save two shillings' worth of hay, and that dissolved sugar added to either hay or straw will increase the value and quality of the hay or straw. In 1809 it was declared in England that "if the use of sugar once becomes general, the price of butchers' meat must certainly be lower, for this plain reason, a much greater quantity of young stock could be raised in many parts of the kingdom, where they now cannot do it, * * * butchers' meat would come within reach of multitudes. Another good effect arising from the use of sugar would be, keeping at home a considerable sum of money which is sent out every year to the ports of our enemies for butter and cheese." It is interesting to note the important role sugar was to play in the navy, such as in the East India Company's service. For "every vessel going on a long voyage * * * one-half the quantity of hay at present consumed on board ship will be sufficient, with the addition of a little molasses or sugar, which occupies so much less room and comes so much cheaper; so that it will have this good effect. * * * Straw, which may be had in most places, or any coarse matter * * * may, by the addition of a little sugar or molasses, be converted into a most nutritive and wholesome food, much superior to hay in point of quality." It was suggested that experiments be made in feeding horses with sugar; it was even, one hundred years ago, pointed out that a horse fed on sugar will show signs of improved condition and have a glossy shining coat, etc. It was then argued that there were certain dangers of over-feeding with sugar, as the animal would become "soft;" with molasses given in small quantities the same difficulties were not to be dreaded. It was recommended that molasses be given either in their drink in the stable bucket, mixed with water, or properly diluted and sprinkled among their chaff, in which case the quantity of hay may be reduced until by degrees none need be given. The great advantages of sugar for stall-fed horses and cattle were thoroughly appreciated in the early part of the century; attention was called to the fact that when put to grass they "will begin to fill and thrive forthwith." On the other hand, "cattle, taken from a straw-yard where they have been indifferently fed during the winter, must be a considerable time on the grass before they recover from the starvation, and, consequently, take up so much time and food to no other purpose, which a thriving animal will convert to immediate profit." Some enthusiasts went so far as to insist upon it that sugar was in reality the principal nutrient found in all feeding stuffs, which has long since been proven to be a very erroneous hypothesis.

Experiments were made upon various animals to determine the practical effects of sugar-feeding; one of the most interesting of these was on an old horse, eighteen years of age, which had been turned out to grass, but which in time was nothing but flesh and bones, and was condemned to be shot; the first week's feeding was with hay and straw, chaff and one-quarter pound molasses diluted with water; the oats allowance was reduced to a quart a day. After eight days the molasses allowance was increased to half a pound per diem, and at the end of a "fortnight there was a visible alteration in the appearance of the horse." After the third week the molasses allowance was still further increased and the animal fed underwent a complete change. In feeding cows with sugar some special advice was given. "It is of particular importance to be very economical as to the quantity given; for whilst a small addition of it to their usual food will be found to improve the quality of their milk, too much, and but a very little too much, will cause them to run to beef more, perhaps, than milk * * * brown sugar is found to contain a considerable quantity of vegetable or essential oil * * * the use of molasses must be the means of a great increase of profit to the butter dairy, and particularly as it can be so conveniently had in winter time, when succulent food is scarce." If sugar were employed in winter, it would diminish the quantity of butter imported. "Sugar or molasses will never from its purity impart any bad taste to the milk, whilst turnips and cabbages, the principal dependence in winter, are both of them apt to give a most rank and disagreeable taste to both butter and milk.'' A hundred years ago it was justly argued that ''should the plan of using molasses become general, we may soon expect to see butter dairies established in the most remote and barren districts of the kingdom.'' It was urged in regard to the use of sugar in the West Indies and the British East Indies (for the colonies were badly supplied with beef) that if sugar feeding were resorted to ''there is no reason why they should not have beef nearly if not entirely as good as that fed in England.''

The following original argument was advanced relative to cattle feeding in very hot climates—''the heat of the climate is not inimical to the operation of fattening so much as the rays of the sun, and if this is properly observed it will clear up a mistake very prevalent. The heat of the weather, at least of the West Indies, is very much in favor of fattening. It is necessary to observe that cattle should be most carefully screened from the rays of the sun. * * * They must be well supplied with water as fresh as possible, into which there should be put as much acid, made of fermented sugar-wash, as will give it a pleasant astringent taste in the mouth, and I would by all means recommend a liberal supply of salt, which is particularly palatable to cattle. * * * A beast getting a sufficient quantity will fatten much sooner, and less food in proportion will do for him than if he did not get any, but above all things it is necessary in a warm climate. * * * It is recommended that the wort which is given to cattle in any hot climate be made for some time before using—just long enough to let it go through as much fermentation as will give it a certain vinosity in its taste, and take off from that heaviness which all sweets are apt to have, and which would perhaps otherwise pall upon the appetite and prevent the animals taking a sufficient quantity.''

Early discussion on cattle feeding with sugar contain many practical suggestions. ''Cattle that are out in the open pasture, where they have plenty of water, do not need much attendance; but where they are confined in a house closely tied up, and have not anything but what is given them, a very little neglect on the part of their keeper will show on them; and though the cause may remain concealed, the effect will be very evident. An injudicious application of the food, giving too much or too little, neglect of watering, in short, any deviation from what is proper will prevent the beast thriving.'' It was urged that no experiments in feeding sugar to cattle be done by persons who may neglect details, for the results obtained would be very misleading.

Oil cake in feeding had at first a certain opposition to contend with, but in the end it became popular. Those using the product claimed that the resultant meat had a peculiar taste, which differed from that obtained when the cattle were fed upon grass. An interesting fact was noticed, that cattle thus fed ''travelled very badly and fell away on the road. These objections by no means exist in the use of sugar; so far from communicating anything disagreeable to the beef, it gives it all that fine rich taste and marbled appearance of the finest grass-fed meat. * * * In the West Indian trade it is the custom to feed cattle in those islands with oil cakes. * * * One is surprised that the most nutritive food in nature * * * has been thrown in their way,'' and not used. As regards feeding molasses to sheep, it was declared that the condition and appearance of the animals would change if the product was given a fair trial. The proposed manner of feeding was as follows: ''Let a quantity of molasses, diluted in water, be sprinkled with a common gardener's-pot and have the sheep driven to the spot; they will not be long there till they find something very palatable in the taste of the grass. * * * They will eat the grass down to the root. By this means they eat away the heart, and in a very short time it will perish and totally disappear, leaving room for a more valuable and useful kind to grow, which the dung of the sheep will contribute to encourage.''

As regards pen feeding, it was declared that ''with molasses and chaff of any description placed in troughs, a mode of management which they will soon come into, they will thrive as well as if wandering over a large pasture. When they once become accustomed to it, the farmer will find it the most expeditious mode of fattening and by far the cheapest; a sheep on sugar-feeding will carry a quantity of fat meat, greater in proportion than on grass-feeding and in a much shorter time.'' While it was once thought that it was not desirable to rear litters of pigs during the winter without the assistance of the dairy, it may be readily ''proved that molasses may be used in rearing young pigs with equal advantage as milk, that they will thrive equally well upon it at any season of the year, amply paying for their keeping, and their litters may be reared as well in winter as in summer.'' The president of the board of agriculture wrote to Ed. T. Waters, Esq., in 1809, asking the following questions in regard to his experiments with molasses in cattle feeding.

Question.	Answer.
(1) What had been the food of the stock previous to the experiments?	(1) Grass.
(2) Were they lean, in good order, or advanced in their fattening?	(2) Good store condition on the first of October, when put to molasses.
(3) Were they confined to stalls or ranging in the field?	(3) Tied up in stalls the first of October, the time of taking from grass.
(4) The progress of the quantity of sugar given, and what other food eaten at the same time?	(4) What hay they would eat, say three trusses per ox per week, with one pound and a half of molasses to three gallon buckets of water; half a pound in each bucket per day.
(5) Did the sugar agree with the stock?	(5) Perfectly.
(6) Respecting the state of their dung?	(6) The dung is an object of material attention, as it is the criterion of their doing well or ill; it should come from them in state of consistency, not to soil themselves.
(7) Were any trials made on the addition of such substances as would prevent the use of sugar for common domestic purposes?	(7) Certainly not.
(8) How long was the trial continued?	(8) My various experiments are of two years' standing.
(9) A local question of price.	
(10) Was any memorandum made of the water drunk more or less than when on other food?	(10) They require less than on other food.

(11) Were any observations made on the quality of the flesh produced by this food? If any trials were made on milch cows, what was the effect on the quality and quantity of the milk?	(11) Nothing could exceed the quality of the flesh, and from the trial I made on milch cows it certainly greatly improved their condition without any visible increase of the quantity of milk.
(12) From the result of your trials, have you found any estimate of the price at which this article of food would be profitable in the use?	(12) The use of the molasses must depend on the price of every other article of a fattening tendency.
(13) Were the stock weighed alive at the commencement of the experiment, or the value ascertained by other means?	(13) No weight of stock taken at the time of putting up; their value increased in as great a proportion as if fed by any other means.
(14) Were the stock slaughtered from sugar or put to other food? If the latter, were they weighed alive, to ascertain the increase—weight gained by the sugar?	(14) The two former sets of oxen were slaughtered from molasses; the last two oxen deemed worthy of notice at Lord Somerville's show were fed on molasses the 1st of February, and the remaining month upon cake.

But between 1850 and 1860 some German investigations were the starting point of considerable information on the subject, and deserve more than a passing notice.

It was very natural that as sugar had been used in the form of molasses for forage combinations, the use of sugar alone should have been thought of. The only obstacle in the way was its excessive price; but in 1874, after the duty on sugar had been done away with in England, renewed efforts were made to feed cattle with it, and little by little this has become a regular practice in that country.

Sugar for general feeding.

In Brazil, chickens and the like have been fed with sugar for many years back. In India it is frequently customary to substitute a portion of cereal for sugar in feeding, with the view to economy.

Sugar gives to all animals to which it is fed the best of appearance, explained by the fact that it is a rational substance, and the mammifera consume considerable quantities in the milk during their early feeding. However, it must be noticed that saccharose does not produce the most desirable effects in all cases, and this may be, in a measure, accounted for by defective digestive organs which vary with the individual.

If sugar is not administered too crudely, heavy rations can do very little harm. The absorption is accomplished in the stomach and in the large intestine. There need be no fear as regards intestinal fermentation. In the case of certain animals, such as pigs and horses, large quantities of sugar can be retained in the stomach and yet undergo no fermentation; when this does occur, it will be produced in the large intestine.

In the case of ruminants, Werther has noticed various digestive complications. Forages when combined with sugar undergo a slow fermentation in the first stomach, in which comparatively little absorption occurs. A certain portion of the cellulose is dissolved, while the other hydrocarbons undergo changes that are in direct ratio to their solubility and their quantity, and for the stock under consideration, a forage containing a large amount of sugar is not desirable.

On the other hand, it may be advantageously used in cases where animals have but one stomach. This decreased digestibility in the case of ruminants has long since been noticed by Grouven and discussed by him very fully.

Lawes has demonstrated that there is every advantage in giving and feeding greater quantities of albuminoids in those cases where considerable sugar is used.

Feeding sugar to calves.

Some very important experiments have been made in the north of France in feeding sugar to calves. The ration consisted mainly of oleomargarine and raw sugar. Every one knows of the value of milk in feeding very young animals, but it is an expensive food and does not give results commensurate with its cost. For many years past efforts have been made to remove the cream and substitute in its place a less costly product, such as cod-liver oil, etc. Several appliances consequently came into existence, permitting a thorough mixing of skimmed milk with fatty substances. The first experiments in this direction were made in this country in the New England States. If oleomargarine is used, it should be heated to 45° to 50° C. (113°–122° F.), and then placed in the mixer; raw sugar is added in the proportion of two parts sugar for one part oleomargarine. When this combination was fed to the calves they fattened at a rate of over 2 lbs. per diem. The resulting meat, while not of the very first quality, brought a very satisfactory price on the market. The French experiments were upon the same lines. By commencing with 60 grams per diem (2.10 oz.) it is possible to force the consumption of oleomargarine to 480 grams (about 1 lb.) for two calves, this being combined with about 18 quarts of skimmed milk. At first about $\frac{1}{10}$ of an ounce of sugar was used for every quart of milk fed. These experiments lasted from November until February. The original weight of the calves was 110 lbs., and their final weight 311 lbs., the daily increase being about 2.3 lbs.

Feeding sugar to pigs.

Practical experiments in Germany seem to show that there is more money to be made in feeding sugar to pigs at the actual price of the market, than to sell it in its raw state. Examples may be given showing that when sugar was selling at $2 per cwt. the resulting increase in swine flesh was worth more than double that amount. Hence if pound per pound increase can be gained by sugar feeding there is that much financial profit.

Experiments in Germany were made upon pigs undergoing two modes of feeding: one with and the other without sugar. The increase in one case was 570 grams per diem, and the other 600 grams, which data, however, offers nothing especially characteristic or interesting.

It was proposed that the protein percentage should be increased in the rations during a period of four weeks, the normal ration with four pigs being per individual and per diem 550 grams while with sugar it was 1 kilo. This increase of weight of 1 kilo per diem, Maercker says, is a new departure in pig feeding, and in order to be profitably applied, it demands special privileges in the way of government taxation. This, it is thought, may be a starting point for numerous changes in the whole question.

The most recent experiments in this direction were with a ration consisting of potatoes, milk, crushed barley and sugar, having a nutritive ratio of 1:8, feeding as much as 12 kilos of sugar per 1000 kilos live weight; pigs of an average weight of 50 kilos to 55 kilos showed an increase in weight per diem of 957 grams, while without sugar, and using the same ration, the increase was only 500 grams.

The Proskau Milk Institution undertook experiments in feeding to pigs a mixture of sugar, rye bran and pulverized meat to determine the economical yield of milk under the respective influences of the substances mentioned; it was concluded that for fattening, sugar does not give the same economical results as cheap fodders, notwithstanding the fact that its use gives excellent results. As to the quality of the resulting meat, its constituents were the least satisfactory. Other experiments of the same kind were conducted at another institution, their object being to determine the comparative value of sugar, starch and molasses. The combinations were such as to retain the same quantities of protein, fatty constituents and non-nitrogenous substances in each fodder used. The molasses was always better than sugar for the purpose in view. Molasses, however, could never prove economical, unless the cost of a pound of sugar in that form was less than the cost of a pound of starch. Molasses did not give any special characteristic to the flesh of the animal fed.

Comparison between sugar and molasses.

Opinions respecting sugar for pigs.

According to Zimmermann, 1 kilo of sugar is followed by 0.72 kilo increase of weight. Lehmann states that this same quantity of sugar will give ½ kilo of fat. It is to be noticed that the fat produced under these circumstances is flabby, but as a general rule the marketable meat increases. The amount that can be fed to growing pigs is 0.5 to 0.75 kilo of first-grade sugar per head and per diem. It is found desirable to add to the ration 10 grams of salt.

In conclusion, as regards the question of pig feeding with sugar, it is to be noted that the best results are obtained with these animals. They do not like sugar, but their organism is so arranged as to derive a benefit from it.

Numerous experiments have been made in feeding sheep with sugar, but most of them have not been a success.

Special sugar combinations.

Mention should also be made of the experiments of Hlavitschka and Drucker, who have transformed fresh blood into a condition that will possess keeping power, by the addition of salt and alcohol. This product is heated to 100° C. with a forage, and is then covered with a slight layer of sugar.

Economic considerations.

In Continental Europe a question which is constantly discussed, is the utilization of the over-production of beet sugar.

Now that there are excellent prospects of the United States manufacturing all the sugar consumed, beet-sugar manufacturers of France and Germany are asking themselves to what new use can sugar be put? The cheapness of sugar on the British market has been the starting point of a new jam and other allied industries, and efforts have been made to feed cattle with sugar that sold for two cents a pound. On certain farms coming under the writer's notice satisfactory results have been obtained. In some experimental stations of France the question has been seriously discussed, and the experiments made by M. Malpeaux, professor of an influential agricultural school of the country are of interest. The importance of sugar in the development of muscle was above referred to, but it is interesting to add that sugar, which is a carbohydrate, also fattens and nourishes man or animal when it is eaten with certain moderation. During the entire century the authorities have never exactly agreed as to the origin of fat in the animal frame, but of late the question has been settled, and the experiments at Rothamsted, England, have demonstrated beyond cavil that sugar could be transformed into fat.

Experimental sugar rations for bulls and heifers.

The practical experiments recently made in France upon bulls and heifers are of more than ordinary interest. The daily rations consisted of 4.4 lbs. clover hay, 11 lbs. oat straw, 66 lbs. special corn fodder, 2.2 lbs. cotton oil cake, 2.2 lbs. grindings of rye and beans, to which was added one pound of sugar. The experiments lasted fifty days; during the first twenty-five days only one bull received sugar, the other animal being used as a standard of comparison; the result was a gain in weight of 6.6 lbs. in favor of sugar. The roles were reversed during the next twenty-five days with an increase of 8.8 lbs. in favor of sugar. The increase of live weight for the bulls with sugar rations was 79.2 lbs., while without sugar it was 63.8 lbs., or a gain of 15.4 lbs. With sugar the first bull had a daily increase of 1.5 lbs., and without sugar the increase was 1.3 lbs.; with sugar the increase per diem of the second bull was 1.7 lbs., and without sugar, 1.3 lbs. With the heifers the increase was even more evident; the first heifer with sugar had a daily increase of 1.7 lbs., and without sugar, 1.5 lb.; with sugar the increase per diem of the second heifer was 1.85 lbs., and without sugar, 1.4 lbs. The conclusion is that the average daily increase in favor of sugar varied from 0.2 lb. to 0.4 lb. An interesting calculation has been made respecting the money profits of sugar-feeding over and above the regular rations, and it is found that for the two bulls it was 11 cents, for the two heifers 32 cents, which amounts are hardly worth considering.

Influence of sugar upon milk.

Very important observations have been made respecting the influence of sugar upon the quantity of milk. Experiments were made upon four cows, and were conducted very much the same as the foregoing. The conclusions were that sugar does not increase the flow of milk, nor does it increase the fatty substances. It was also shown that sugar in the ration has no influence upon the casein and the percentage of lactose is not modified. Mineral salts were found to be 7 per cent. with or without sugar. The proportion of free and volatile acids increases in butter from cows having received sugar in moderate quantities. The fact is, none of these experiments can be considered as conclusive; hence the importance of still further investigation. It is thought that if it were possible to determine by a certain formula the amount of sugar to be used in combination with a well-combined ration very different results from those under consideration would be obtained, and the advantages of sugar would then be demonstrated; but as this has yet to be done, the present outlook does not seem favorable for its general use when milk, cream and butter are the objects in view. On the other hand, for fattening purposes there can be no doubt that in countries where sugar is very cheap, such as England, a farmer would find it to his advantage to use sugar in the daily rations of animals being fattened.

Feeding horses with sugar.

As early as 1880 Prof. Grandeau commenced a series of experiments in Paris to determine what sort of feed was best suited for horses, when at rest in the stable, when walking and trotting, also when working slowly and rapidly, etc. All these experiments, without an exception, have led to the very important conclusion that for the producton of energy and work the most important element to be furnished is an ample supply of carbohydrates; nitrogen entered the working ration to make up for slight muscle losses. The important part of the conclusion is that there is an actual economy in the utilization of the amylaceous principles of fodders as compared with the nitrogenous elements. During 1898 experiments were made to determine what influence sugar had when fed in different quantities. The full details of the observations are not at hand, but an outline of the principal results is not without interest. The experiments were upon three horses, as near the same build, age, weight, etc., as was possible. All the urine and excrements were collected and analyzed; the weight of the fodder consumed was exactly determined; the volume of water drunk exactly noted; the horses were weighed several times a day. The quantity of sugar fed daily varied from 600 grams to 2.400 kilos (1.32 lbs. to 5.4 lbs.) per diem. The feeds used, either alone or combined with sugar, were hay, oat-straw and corn. Maltine was the principal source of nitrogen. The following table shows the results:

EXPERIMENTAL RATIONS FED TO HORSES (1898).

FEED.	Substances digested per horse and per diem.		Digestible substances per 100 kilos, live weight.	Nutritive ratio.	Caloric value.
	Nitrogenous.	Non-nitrogenous.			
	Grams.	Grams.	Kilos.		Cal.
Hay (alone)	263.8	2,979.5	7,800	1:11.3	13,429.4
Hay and sugar.......	318.4	4,298.2	11,300	1:13.6	19,070.7
Maltine	778.1	4,388.6	13,100	1:5.6	21,572.6
Corn and sugar	243.0	5,422	13,900	1:22.3	23.339.6

The practical conclusions to be drawn from these different rations are given in the following table:

RESULTS OF RATIONS AS TO WORK AND WEIGHT (1898).

FEED.	Work accomplished.	Water drunk per kilo of dry substance.	Daily variation in the weight of the horse.
	Kilogrammeter.		Kilos.
Hay (alone)	230,189	3,833	—0.300
Hay and sugar	230,497	3,000	+0.120
Maltine	221,906	3,900	+0.128
Corn and sugar..............	262,920	1,900	—0.200

This data shows that of all the feeds used for working horses, hay is the least desirable for keeping the animal in a normal condition. The maximum work was accomplished with a ration containing the smallest percentage of nitrogenous elements (243 grams ration corn and sugar), and the richest in hydrocarbons, mainly sugar (5.422 kilos, or nearly 12 lbs.). The work increased with the caloric value of the ration, and the sugar ration in every respect was the most desirable. An interesting paradox in these experiments, and to many it will be a source of astonishment, was that the thirst of the animal did not increase with the quantity of sugar consumed. The most work was accomplished when the nutritive ratio was only 1:22.3, and the horse receiving the largest amount of nitrogenous feed, accomplished the least.

Difficulties to contend with in European sugar feeding.

A great obstacle found in the use of sugar as a forage in Europe, up to the present time at least, has been the fiscal question, as both in Germany and France the home taxation of the product is such that its expense is too great for its general introduction for feeding. On the part of these Governments, there has always been a certain apprehension of the possibility of frauds arising from the withdrawal of the existing modes of taxation. It has been suggested that sugar be mixed with vermouth powder, also lamp soot and salt, so as to render its use for human consumption impossible. Gonnermann has lately proposed the denaturation of sugar by the means of peat. The German government in 1891 made some changes in the existing law and determined that the denaturated sugar should not be taxed provided it was made under the control of the state.

Feeding Standards.*

A—Per Day and One Thousand Pounds Live Weight.†

Cattle fed.	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbohydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Oxen at rest in stall	17.5	0.7	8 3	9.0	1:11.9
Wool sheep, coarser breeds	20.0	1.2	10.8	12.0	1: 9.0
Wool sheep, finer breeds	22.5	1.5	12.0	13.5	1: 8.0
Oxen moderately worked	24.0	1.6	12.0	13.6	1: 7.5
Oxen heavily worked	26.0	2.4	14.3	16.7	1: 6.0
Horses lightly worked	20.0	1.5	10.4	11.9	1: 6.9
Horses moderately worked	21.0	1.7	11.8	13.5	1: 6.9
Horses heavily worked	23.0	2.3	14.3	16.6	1: 6.2
Milk cows, Wolff's standard	24.0	2.5	13 4	15.9	1: 5.4
Milk cows, Wisconsin standard	24.5	2.2	14.9	17.1	1: 6.8
Fattening oxen, preliminary period	27.0	2.5	16.1	18.6	1: 6.4
Fattening oxen, main period	26.0	3.0	16.4	19.4	1: 5.5
Fattening oxen, finishing period	25.0	2.7	16.2	18.9	1: 6.0
Fattening sheep, preliminary period	26.0	3.0	16.3	19.3	1: 5.4
Fattening sheep, main period	25.0	3.5	15.8	19.3	1: 4.5
Fattening swine, preliminary period	36.0	5.0	27.5	32.5	1: 5.5
Fattening swine, main period	31.0	4.0	24.0	28.0	1: 6.0
Fattening swine, finishing period	23.5	2.7	17.5	20.2	1: 6.5
Growing cattle:					
Age. Months. — Average live weight per head.					
2—3 — 150 lbs.	22.0	4.0	18.3	22 3	1: 4.6
3—6 — 300 lbs.	23.4	3.2	15.8	19.0	1: 4.9
6—12 — 500 lbs.	24.0	2.5	14.9	17.4	1: 6.0
12—18 — 700 lbs.	24.0	2.0	13.9	15.9	1: 7.0
18—24 — 850 lbs.	24.0	1.6	12.7	14.3	1: 8.0
Growing sheep:					
5—6 — 56 lbs.	28.0	3.2	17.4	20.6	1: 5.4
6—8 — 67 lbs.	25.0	2.7	14.7	17.4	1: 5.4
8—11 — 75 lbs.	23.0	2.1	12.5	14.6	1: 6.0
11—15 — 82 lbs.	22.5	1.7	11.8	13.5	1: 7.0
15—20 — 85 lbs.	22.0	1.4	11.1	12.5	1: 8.0

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* These feeding standards are taken mainly from German sources, but have been arranged by Armsby, "Circular of Information No. 1," Pennsylvania State College.

† The fattening rations are calculated for one thousand pounds live weight at the beginning of the fattening.

B—Per Day and Head.

Cattle fed.		Dry matter.	Digestible.			Nutritive ratio.
			Protein.	Carbohydrates and fat.	Total.	
Growing fat pigs:		Lbs.	Lbs.	Lbs.	Lbs.	
Age. Months.	Average live weight per head.					
2—3	50 lbs.	42.0	7.5	30.0	37.5	1:4.0
3—5	100 lbs.	34.0	5.0	25.0	30.0	1:5.0
5—6	125 lbs.	31.5	4.3	23.7	28.0	1:5.5
6—8	170 lbs.	27.0	3.4	20.4	23.8	1:6.0
8—12	250 lbs.	21.0	2.5	16.2	18.7	1:6.5
Growing cattle:						
2—3	150 lbs.	3.3	0.6	2.8	3.4	1:4.6
3—6	300 lbs.	7.0	1.0	4.9	5.9	1:4.9
6—12	500 lbs.	12.0	1.3	7.5	8.8	1:6.0
12—18	700 lbs.	16.8	1.4	9.7	11.1	1:7.0
18—24	850 lbs.	20.4	1.4	11.1	12.5	1:8.0
Growing sheep:						
5—6	56 lbs.	1.6	0.18	0.974	1.154	1:5.4
6—8	67 lbs.	1.7	0.18	0.981	1.161	1:5.4
8—11	75 lbs.	1.7	0.16	0.953	1.113	1:6.0
11—15	82 lbs.	1.8	0.14	0.975	1.115	1:7.0
15—20	85 lbs.	1.9	0.12	0.955	1.075	1:8.0
Growing fat swine:						
2—3	50 lbs.	2.1	0,38	1.50	1.88	1:4.0
3—5	100 lbs.	3.4	0.50	2.50	3.00	1:5.0
5—6	125 lbs.	3.9	0.54	2.96	3.50	1.5.5
6—8	170 lbs.	4.6	0.58	3.47	4.05	1:6.0
8—12	250 lbs.	5.2	0.62	4.05	4.67	1:6.5

Table for Computing Rations for Farm Animals.*

DIGESTIBLE NUTRIENTS IN STATED AMOUNTS OF THE MORE COMMON FEEDING STUFFS.

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
SOILING FODDER.					
Fodder corn, 1 lb	.20	.010	.125	.135	1:12.5
“ “ 5 lbs	1.00	.050	.625	.675	
“ “ 15 “	3.00	.150	1.875	2.025	
“ “ 20 “	4.00	.200	2.500	2.700	
“ “ 25 “	5.00	.250	3.125	3.375	
“ “ 30 “	6.00	.300	3.750	4.050	
“ “ 35 “	7.00	.350	4.375	4.725	
“ “ 40 “	8.00	.400	5.000	5.400	
Peas and oats, 1 lb	.16	.018	.076	.094	1:4.2
“ “ 5 lbs	.80	.090	.380	.470	
“ “ 15 “	2.40	.270	1.140	1.410	
“ “ 20 “	3.20	.360	1.520	1.880	
“ “ 25 “	4.00	.450	1.900	2.350	
“ “ 30 “	4.80	.540	2.280	2.820	
“ “ 35 “	5.60	.630	2.660	3.290	
“ “ 40 “	6.40	.720	3.040	3.760	
Peas and barley	.16	.017	.077	.094	1:4.5
Practically the same as peas and oats.					
Red clover, 1 lb	.29	.029	.164	.193	1:5.6
“ “ 5 lbs	1.45	.145	.820	.965	
“ “ 15 “	4.35	.435	2.460	2.895	
“ “ 20 “	5.80	.580	3.280	3.860	
“ “ 25 “	7.25	.725	4.100	4.825	
“ “ 30 “	8.70	.870	4.920	5.790	
“ “ 35 “	10.15	1.015	5.740	6.755	
“ “ 40 “	11.60	1.160	6.560	7.720	
Alfalfa, 1 lb	.28	.039	.138	.177	1:3.5
“ 5 lbs	1.40	.195	.690	.885	
“ 15 “	4.20	.585	2.070	2.655	
“ 20 “	5.60	.780	2.760	3.540	
“ 25 “	7.00	.975	3.450	4.425	

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* These well combined tables are taken from Bulletin 154, Cornell University Agricultural Experiment Station, Ithaca, New York. The arrangement is such as to be a means of saving time and allows a comparison with standards.

Digestible Nutrients.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutriti ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Alfalfa, 30 lbs	8.40	1.170	4.140	5.310	
" 35 "	9.80	1.365	4.830	6.195	
" 40 "	11.20	1.560	5.520	7.080	
Hungarian grass, 1 lb...	.29	.020	.169	.189	1:8.4
" " 5 lbs..	1.45	.100	.845	.945	
" " 15 " ..	4.35	.300	2.535	2.835	
" " 20 " ..	5.80	.400	3.380	3.780	
" " 25 " ..	7.25	.500	4.225	4.725	
" " 30 " ..	8.70	.600	5.070	5.670	
" " 35 " ..	10.15	.700	5.915	6.615	
" " 40 " ..	11.60	.800	6.760	7.560	
Corn silage, 1 lb........	.21	.009	.129	.138	1:14.3
" " 5 lbs	1.05	.045	.645	.690	
" " 15 "	3.15	.135	1.935	2.070	
" " 20 "	4.20	.180	2.580	2.760	
" " 25 "	5.25	.225	3.225	3.450	
" " 30 "	6.30	.270	3.870	4.140	
" " 35 "	7.35	.315	4.515	4.830	
" " 40 "	8.40	.360	5.160	5.520	
" " 45 "	9.45	.405	5.805	6.210	
" " 50 "	10.50	.450	6.450	6.900	
ROOTS AND TUBERS.					
Potatoes, 1 lb	.21	.009	.165	.174	1:18.3
" 5 lbs	1.05	.045	.825	.870	
" 15 "	3.15	.135	2.475	2.610	
" 20 "	4.20	.180	3.300	3.480	
" 25 "	5.25	.225	4.125	4.350	
Beet, mangel, 1 lb......	.09	.011	.056	.067	1:5.1
" " 5 lbs.....	.45	.055	.280	.335	
" " 15 "	1.35	.165	.840	1.005	
" " 20 "	1.80	.220	1.120	1.340	
" " 25 "	2.25	.275	1.400	1.675	
" " 30 "	2.70	.330	1.680	2.010	
Beet, sugar, 1 lb	.13	.011	.104	.115	1:9.4
" " 5 lbs	.65	.055	.520	.575	
" " 15 "	1.95	.165	1.560	1.725	
" " 20 "	2.60	.220	2.080	2.300	

Digestible Nutrients.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25.)	Total.	
Beet, sugar, 25 lbs.	3.25	2.75	2.600	2.875	
" " 30 "	3.90	3.30	3.120	3.450	
Carrot, 1 lb	.11	.008	.082	.090	1:10.3
" 5 lbs	.55	.040	.410	.450	
" 15 "	1.65	.120	1.230	1.350	
" 20 "	2.20	.160	1.640	1.800	
" 25 "	2.75	.200	2.050	2.250	
" 30 "	3.30	.240	2.460	2.700	
HAY AND STRAW.					
Timothy, 1 lb.	.87	.028	.465	.493	1:16.6
" 3 lbs.	2.61	.084	1.395	1.479	
" 5 "	4.35	.140	2.325	2.465	
" 7 "	6.09	.196	3.255	3.451	
" 8 "	6.96	.224	3.720	3.944	
" 9 "	7.83	.252	4.185	4.437	
" 12 "	10.44	.336	5.580	5.916	
" 15 "	13.05	.420	6.975	7.395	
" 18 "	15.66	.504	8.370	8.874	
" 20 "	17.40	.560	9.300	9.860	
Mixed grasses and clover, 1 lb.	.87	.062	.460	.522	1: 7.4
" 3 lbs.	2.61	.186	1.381	1.566	
" 5 "	4.35	.310	2.300	2.610	
" 7 "	6.09	.434	3.220	3.654	
" 8 "	6.96	.496	3.680	4.176	
" 9 "	7.83	.558	4.140	4.698	
" 12 "	10.44	.744	5.520	6.264	
" 15 "	13.05	.930	6.900	7.830	
" 18 "	15.66	1.116	8.280	9.396	
" 20 "	17.40	1.240	9.200	10.440	
Hungarian hay, 1 lb.	.92	.045	.546	.591	1:12.1
" " 3 lbs.	2.76	.135	1.638	1.773	
" " 5 "	4.60	.225	2.730	2.955	
" " 7 "	6.44	.315	3.822	4.137	
" " 8 "	7.36	.360	4.368	4.728	
" " 9 "	8.28	.405	4.914	5.319	
" " 12 "	11.04	.540	6.552	7.092	

DIGESTIBLE NUTRIENTS.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25.)	Total.	
Red clover hay, 1 lb.	.85	.068	.396	.464	1: 5.8
" " 3 lbs	2.55	.204	1.188	1.392	
" " 5 "	4.25	.340	1.980	2.320	
" " 7 "	5.95	.476	2.772	3.248	
" " 8 "	6.80	.544	3.168	3.712	
" " 9 "	7.65	.612	3.564	4.176	
" " 12 "	10.20	.816	4.752	5.568	
" " 15 "	12.75	1.020	5.940	6.960	
" " 18 "	15.30	1.224	7.128	8.352	
" " 20 "	17.00	1.360	7.920	9.280	
Alfalfa hay, 1 lb.	.92	.110	.423	.533	1: 3.8
" " 3 lbs	2.76	.330	1.269	1.599	
" " 5 "	4.60	.550	2.115	2.665	
" " 7 "	6.44	.770	2.961	3.731	
" " 8 "	7.36	.880	3.384	4.264	
" " 9 "	8.28	.990	3.807	4.797	
" " 12 "	11.04	1.320	5.076	6.396	
" " 15 "	13.80	1.650	6.345	7.995	
" " 18 "	16.56	1.980	7.614	9.594	
" " 20 "	18.40	2.200	8.460	10.660	
Corn fodder, 1 lb.	.58	.025	.373	.398	1:14.9
" 5 lbs	2.90	.125	1.865	1.990	
" 8 "	4.64	.200	2.984	3.184	
" 12 "	6.96	.300	4.476	4.776	
" 15 "	8.70	.375	5.595	5.970	
" 18 "	10.44	.450	6.714	7.164	
" 20 "	11.60	.500	7.460	7.960	
Corn stover, 1 lb.	.60	.017	.340	.357	1:19.9
" 5 lbs	3.00	.085	1.720	1.785	
" 8 "	4.80	.136	2.720	2.856	
" 12 "	7.20	.204	4.080	4.284	
" 15 "	9.00	.255	5.160	5.355	
" 18 "	10.80	.306	6.120	6.426	
" 20 "	12.00	.340	6.880	7.140	
Pea-vine straw, 1 lb.	.86	.043	.341	.384	1: 7.9
" " 3 lbs	2.58	.129	1.023	1.152	
" " 5 "	4.30	.215	1.705	1.920	
" " 8 "	6.88	.344	2.728	3.072	
" " 12 "	10.32	.516	4.092	4.608	
" " 15 "	12.90	.645	5.115	5.760	

DIGESTIBLE NUTRIENTS. —*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25.)	Total.	
Wheat straw, 1 lb	.90	.004	.372	.376	1:93.
“ 3 lbs	2.70	.012	1.016	1.128	
“ 5 “	4.50	.020	1.860	1.880	
“ 8 “	7.20	.032	2.976	3.008	
“ 12 “	10.80	.048	4.064	4.512	
“ 15 “	13.50	.060	5.580	5.640	
Oat straw, 1 lb	.91	.012	.404	.416	1:33.6
“ 3 lbs	2.73	.036	1.212	1.248	
“ 5 “	4.55	.060	2.020	2.080	
“ 8 “	7.28	.096	3.232	3.328	
“ 12 “	10.92	.144	4.848	4.992	
“ 15 “	13.65	.180	6.060	6.240	
GRAIN.					
Corn (av.) 1 lb	.89	.079	.764	.843	1:9.7
“ 2 lbs	1.78	.158	1.528	1.686	
“ 3 “	2.67	.237	2.292	2.529	
“ 4 “	3.56	.316	3.056	3.372	
“ 5 “	4.45	.395	3.820	4.215	
“ 6 “	5.34	.474	4.584	5.058	
“ 7 “	6.23	.553	5.348	5.901	
“ 8 “	7.12	.632	6.112	6.744	
“ 9 “	8.01	.711	6.876	7.587	
Wheat, 1 lb	.90	.102	.730	.832	1:7.2
“ 2 lbs...........	1.80	.204	1.460	1.664	
“ 3 “	2.70	.306	2.190	2.496	
“ 4 “	3.60	.408	2.920	3.328	
“ 5 “	4.50	.510	3.650	4.160	
“ 6 “	5.40	.612	4.380	4.992	
Rye, 1 lb.............	.88	.099	.700	.799	1:7.1
“ 2 lbs	1.76	.198	1.400	1.598	
“ 3 “	2.64	.297	2.100	2.397	
“ 4 “	3.52	.396	2.800	3.196	
“ 5 “	4.40	.495	3.500	3.995	
“ 6 “	5.28	.594	4.200	4.794	
Barley, 1 lb	.89	.087	.692	.779	1:7.9
“ 2 lbs	1.78	.174	1.384	1.558	
“ 3 “	2.67	.261	2.076	2.337	

DIGESTIBLE NUTRIENTS.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Barley, 4 lbs	3.56	.348	2.768	3.116	
“ 5 “	4.45	.435	3.460	3.895	
“ 6 “	5.34	.522	4.152	4.674	
Oats, 1 lb.	.89	.092	.568	.660	1: 6.2
“ 2 lbs	1.78	.184	1.136	1.320	
“ 3 “	2.67	.276	1.704	1.980	
“ 4 “	3.56	.368	2.272	2.640	
“ 5 “	4.45	.460	2.840	3.300	
“ 6 “	5.34	.552	3.408	3.960	
“ 7 “	6.23	.644	3.976	4.620	
“ 8 “	7.12	.736	4.544	5.280	
“ 9 “	8.01	.828	5.112	5.940	
“ 12 “	10.68	1.104	6.816	7.920	
“ 15 “	13.35	1.380	8.520	9.900	
Buckwheat, 1 lb	.87	.077	.533	.610	1: 6.9
“ 2 lbs	1.74	.154	1.066	1.220	
“ 3 “	2.61	.231	1.599	1.830	
“ 4 “	3.48	.308	2.132	2.440	
“ 5 “	4.35	.385	2.665	3.050	
“ 6 “	5.22	.462	3.198	3.660	
“ 7 “	6.09	.539	3.731	4.270	
“ 8 “	6.96	.616	4.264	4.880	
“ 9 “	7.83	.693	4.797	5.490	
Peas, 1 lb.	.90	.168	.534	.702	1: 3.2
“ 2 lbs	1.80	.336	1.068	1.404	
“ 3 “	2.70	.504	1.602	2.106	
“ 4 “	3.60	.672	2.136	2.808	
“ 5 “	4 50	.840	2.670	3.510	
“ 6 “	5.40	1.008	3.204	4.212	
“ 7 “	6.30	1.176	3.738	4.914	
“ 8 “	7.20	1.344	4.272	5.616	
“ 9 “	8.10	1.512	4.806	6.318	
MILL PRODUCTS.					
Corn and cob meal, 1 lb.	.85	.044	.665	.709	1:15.1
“ “ 2 lbs	1.70	.088	1.330	1.418	
“ “ 3 “	2.55	.132	1.995	2.127	
“ “ 4 “	3.40	.176	2.660	2.836	
“ “ 5 “	4.25	.220	3.325	3.545	

DIGESTIBLE NUTRIENTS.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Corn and cob meal, 6 lbs..	5.10	.264	3.990	4.254	
" " 7 " ..	5.95	.308	4.655	4.963	
" " 8 " ..	6.80	.352	5.320	5.672	
" " 9 " ..	7.65	.396	5.985	6.381	
" " 12 " ..	10.20	.528	7.980	8.508	
Wheat bran, 1 lb........	.88	.122	.453	.575	1:3.7
" " 2 lbs.......	1.76	.244	.906	1.150	
" " 3 "	2.64	.366	1.359	1.725	
" " 4 "	3.52	.488	1.812	2.300	
" " 5 "	4.40	.610	2.265	2.875	
" " 6 "	5.28	.732	2.718	3.450	
" " 7 "	6.16	.854	3.171	4.025	
" " 8 "	7.04	.976	3.624	4.600	
" " 9 "	7.92	1.098	4.077	5.175	
Wheat middlings, 1 lb....	.88	.128	.607	.735	1:4.7
" " 2 lbs...	1.76	.256	1.214	1.470	
" " 3 " ...	2.64	.384	1.821	2.205	
" " 4 " ...	3.52	.512	2.428	2.940	
" " 5 " ...	4.40	.640	3.035	3.675	
" " 6 " ...	5.28	.768	3.642	4.410	
" " 7 " ...	6.16	.896	4.249	5.145	
" " 8 " ...	7.04	1.024	4.856	5.880	
" " 9 " ...	7.92	1.152	5.463	6.615	
Dark feeding flour, 1 lb ..	.90	.135	.658	.793	1:4.9
" " 2 lbs..	1.80	.270	1.316	1.586	
" " 3 " ..	2.70	.405	1.974	2.379	
" " 4 " ..	3.60	.540	2.632	3.172	
" " 5 " ..	4.50	.675	3.290	3.965	
" " 6 " ..	5.40	.810	3.948	4.758	
" " 7 " ..	6.30	.945	4.606	5.551	
" " 8 " ..	7.20	1.080	5.264	6.344	
" " 9 " ..	8.10	1.215	5.922	7.137	
Low grade flour, 1 lb	.88	.082	.647	.729	1:7.9
" " " 2 lbs....	1.76	.164	1.294	1.458	
" " " 3 "	2.64	.246	1.941	2.187	
" " " 4 "	3.52	.328	2.588	2.916	
" " " 5 "	4.40	.410	3.235	3.645	
" " " 6 "	5.28	.492	3.882	4.374	

DIGESTIBLE NUTRIENTS.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Low grade flour, 7 lbs.	6.16	.574	4.529	5.103	
" " 8 "	7.04	.656	5.176	5.832	
" " 9 "	7.92	.738	5.823	6.561	
Rye bran, 1 lb.	.88	.115	.548	.663	1:4.8
" 2 lbs.	1.76	.230	1.096	1.326	
" 3 "	2.64	.345	1.644	1.989	
" 4 "	3.52	.460	2.192	2.652	
" 5 "	4.40	.575	2.740	3.315	
" 6 "	5.28	.690	3.288	3.978	
" 7 "	6.16	.805	3.836	4.641	
" 8 "	7.04	.920	4.384	5.304	
" 9 "	7.92	1.035	4.952	5.967	
Buckwheat bran, 1 lb.	.90	.074	.347	.421	1:4.7
" " 2 lbs.	1.80	.148	.694	.842	
" " 3 "	2 70	.222	1.041	1.263	
" " 4 "	3.60	.296	1.388	1.684	
" " 5 "	4.50	.370	1.735	2.105	
" " 6 "	5.40	.444	2.082	2.526	
" " 7 "	6.30	.518	2.429	2.847	
" " 8 "	7.20	.592	2 776	3.368	
" " 9 "	8.10	.666	3.123	3.789	
Buckwheat middlings, 1 lb.	.87	.220	.456	.676	1:2.1
" " 2 lbs.	1.74	.440	.912	1.352	
" " 3 "	2.61	.660	1.368	2.028	
" " 4 "	3.48	.880	1.824	2.704	
" " 5 "	4.35	1.100	2.280	3.380	
" " 6 "	5.22	1.320	2.736	4.056	
" " 7 "	6.09	1.540	3.192	4.732	
" " 8 "	6.96	1.760	3.648	5.408	
" " 9 "	7.83	1.980	4.104	6.084	
BY-PRODUCTS.					
Malt sprouts, 1 lb.	.90	.186	.409	.595	1:2.2
" 2 lbs.	1.80	.372	.818	1.190	
" 3 "	2.70	.558	1.227	1.785	
" 4 "	3.60	.744	1.636	2.380	
" 5 "	4.50	.930	2.045	2.975	
" 6 "	5.40	1.116	2.454	3.570	

DIGESTIBLE NUTRIENTS.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Malt Sprouts, 7 lbs	6.30	1.302	2.863	4.165	
" 8 "	7.20	1.488	3.272	4.760	
" 9 "	8.10	1.674	3.681	5.355	
Brewer's grains, wet, 1 lb.	.24	.039	.125	.164	1:3.2
" " 2 lbs.	.48	.078	.250	.328	
" " 3 "	.72	.117	.375	.492	
" " 4 "	.96	.156	.500	.656	
" " 5 "	1.20	.195	.625	.820	
" " 6 "	1.44	.234	.750	.984	
" " 7 "	1.68	.273	.875	1.148	
" " 8 "	1.92	.312	1.000	1.312	
" " 9 "	2.16	.351	1.125	1.476	
" " 11 "	2.64	.429	1.375	1.804	
" " 12 "	2.88	.468	1.500	1.968	
" " 15 "	3.60	.585	1.875	2.460	
Brewer's grains, dry, 1 lb.	.92	.157	.478	.635	1:3
" " 2 lbs.	1.84	.314	.956	1.270	
" " 3 "	2.76	.471	1.434	1.905	
" " 4 "	3.68	.628	1.912	2.540	
" " 5 "	4.60	.785	2.390	3.175	
" " 6 "	5.52	.942	2.868	3.810	
" " 7 "	6.44	1.099	3.346	4.445	
" " 8 "	7.36	1.256	3 824	5.080	
" " 9 "	8.28	1.413	4.302	5.715	
Gluten feed, 1 lb	.92	.194	.633	.827	1:3.3
" 2 lbs	1.84	.388	1.266	1.654	
" 3 "	2.76	.582	1.899	2.481	
" 4 "	3.68	.776	2.532	3.308	
" 5 "	4.60	.970	3.165	4.135	
" 6 "	5.52	1.164	3.798	4.962	
" 7 "	6.44	1.358	4.431	5.789	
" 8 "	7.36	1.552	5.064	6.616	
Gluten meal, 1 lb	.92	.258	.656	.914	1:2.5
" 2 lbs.......	1.84	.516	1.312	1.828	
" 3 ".......	2.76	.774	1.968	2.742	
" 4 ".......	3.68	1.032	2.624	3.656	
" 5 ".......	4.60	1.290	3.280	4.570	
" 6 ".......	5.52	1.548	3.936	5.484	

Digestible Nutrients.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.24).	Total.	
Gluten meal, 7 lbs......	6.44	1.806	4 592	6.398	
“ 8 “	7.36	2.064	5.248	7.312	
Hominy chop, 1 lb.......	.89	.075	.705	.780	1:9.4
“ 2 lbs......	1.78	.150	1.410	1.560	
“ 3 “	2.67	.225	2.115	2.340	
“ 4 “	3.56	.300	2.820	3.120	
“ 5 “	4.45	.375	3.525	3.900	
“ 6 “	5.34	.450	4.230	4.680	
“ 7 “	6.23	.525	4.935	5.460	
“ 8 “	7.12	.600	5.640	6.240	
“ 9 “	8.01	.675	6 345	7.020	
Linseed meal (old process), 1 lb.......	.91	.293	.485	.778	1:1.7
“ “ 2 lbs......	1.82	.586	.970	1.556	
“ “ 3 “	2.73	.879	1.455	2.334	
“ “ 4 “	3.64	1.172	1.940	3.112	
“ “ 5 “	4.55	1.465	2.425	3.890	
“ “ 6 “	5.46	1.758	2 910	4.668	
“ “ 7 “	6 37	2.051	3.395	5.446	
Linseed meal (new process), 1 lb.......	.90	.282	.464	.746	1:1.6
“ “ 2 lbs......	1.80	.564	.928	1.492	
“ “ 3 “	2.70	.846	1.392	2.238	
“ “ 4 “	3.60	1.128	1.856	2 984	
“ “ 5 “	4.50	1.410	2.320	3.730	
“ “ 6 “	5.40	1.692	2.784	4.476	
“ “ 7 “	6.30	1.974	3.248	5.232	
Cotton-seed meal, 1 lb....	.92	.372	.444	.816	1:1.2
“ “ 2 lbs...	1.84	.744	.888	1.632	
“ “ 3 “ ...	2.76	1.116	1.332	2.448	
“ “ 4 “ ...	3.68	1.488	1.776	3.264	
“ “ 5 “ ...	4.60	1.860	2.220	4.080	
“ “ 6 “ ...	5.52	2.232	2.664	4.896	
“ “ 7 “ ...	6.44	2.604	3.008	5.712	
“ “ 8 “ ...	7.36	2.976	3.552	6 528	
“ “ 9 “ ...	8.28	3.348	3.996	7.344	
MISCELLANEOUS.					
Cabbage, 1 lb...........	.15	.018	.091	.109	1:5.1
“ 5 lbs..........	.75	.090	.455	.545	

DIGESTIBLE NUTRIENTS.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Cabbage, 15 lbs	2.25	.270	1.365	1.635	
“ 20 “	3.00	.360	1.820	2.180	
“ 25 “	3.75	.450	2.275	2.725	
“ 30 “	4.50	.540	2.730	3.270	
“ 35 “	5.25	.630	3.185	3.815	
“ 40 “	6.00	.720	3.640	4.360	
Sugar beet leaves, 1 lb.	.12	.017	.051	.068	1:3
“ “ 5 lbs	.60	.085	.255	.340	
“ “ 15 “	1.80	.255	.765	1.020	
“ “ 20 “	2.40	.340	1.020	1.360	
“ “ 25 “	3.00	.425	1.275	1.700	
“ “ 30 “	3.60	.510	1.530	2.040	
“ “ 35 “	4.20	.595	1.785	2.380	
“ “ 40 “	4.80	.680	2.040	2.720	
Sugar beet pulp, 1 lb.	.10	.006	.073	.079	1:12
“ “ 5 lbs	.50	.030	.365	.395	
“ “ 15 “	1.50	.090	1.095	1.185	
“ “ 20 “	2.00	.120	1.460	1.580	
“ “ 25 “	5.20	.150	1.825	1.975	
“ “ 30 “	3.00	.180	2.190	2.370	
“ “ 35 “	3.50	.210	2.555	2.765	
“ “ 40 “	4.00	.240	2.920	3.160	
Beet molasses, 1 lb.	.79	.091	.595	.696	1:6.5
“ “ 2 lbs	1.58	.182	1.190	1.372	
“ “ 3 “	2.37	.273	1.785	2.058	
“ “ 4 “	3.16	.364	2.380	2.744	
“ “ 5 “	3.95	.455	2.975	3.430	
“ “ 6 “	4.74	.546	3.570	4.116	
“ “ 7 “	5.53	.637	4.165	4.802	
“ “ 8 “	6.32	.728	4.760	5.488	
“ “ 9 “	7.11	.819	5.355	6.174	
Apple pomace, 1 lb.	.233	.011	.164	.175	1:14.9
“ “ 5 lbs	1.165	.055	.820	.875	
“ “ 15 “	3.495	.165	2.460	2.625	
“ “ 20 “	4.660	.220	3.280	3.500	
“ “ 25 “	5.825	.275	4.100	4.375	
“ “ 30 “	6.990	.330	4.920	5.250	

DIGESTIBLE NUTRIENTS.—*Concluded.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Apple pomace, 35 lbs......	8.155	.385	5.740	6.125	
“ “ 40 “	9.320	.440	6.560	7.000	
Skim milk gravity, 1 lb. ..	.096	.031	.065	.096	1:2.1
“ “ 5 lbs ..	.480	.155	.325	.480	
“ “ 8 “ ..	.768	.248	.520	.768	
“ “ 12 “ ..	1.152	.372	.780	1.152	
“ “ 15 “ ..	1.440	.465	.975	1.440	
“ “ 20 “ ..	1.920	.620	1.300	1.920	
“ “ 25 “ ..	2.400	.775	1.625	2.400	
“ “ 30 “ ..	2.880	.930	1.950	2.880	
Skim milk centrifugal, 1 lb .	.094	.029	.059	.088	1:2
“ “ 5 lbs.	.470	.145	.295	.440	
“ “ 8 “.	.752	.232	.472	.704	
“ “ 12 “.	1.128	.348	.708	1.056	
“ “ 15 “.	1.410	.435	.885	1.320	
“ “ 20 “.	1.880	.580	1.180	1.760	
“ “ 25 “.	2.350	.725	1.475	2.200	
“ “ 30 “.	2.820	.870	1.770	2.620	
Buttermilk, 1 lb..........	.10	.039	.065	.104	1:1.7
“ 5 lbs	.50	.195	.325	.520	
“ 8 “	.80	.312	.520	.832	
“ 12 “	1.20	.468	.780	1.248	
“ 15 “	1.50	.585	.975	1.560	
“ 20 “	2.00	.780	1.300	2.080	
“ 25 “	2.50	.975	1.625	2.600	
“ 30 “	3.00	1.170	1.950	3.120	

PART SIXTH.

Definitions and Technical Considerations.

Albuminoids. The albuminoids belong to the so-called protein classification, which exists in many forms, such as gluten, vegetable albumins, etc. As their name indicates, they resemble in composition the white of egg. When in a soluble form, they may be rendered insoluble through the action of heat. There follows a coagulation. Albuminoids are made up of carbon, hydrogen, oxygen and nitrogen, with a small amount of sulphur. There is a great variation of these elements in the different forms in which the albuminoids are found. In the case of nitrogen, it is supposed that 16 per cent. is about an average, hence it is customary to multiply the percentage of nitrogen found by analysis by 6.25; this is only an approximation, but is accepted. The word albuminoids is another term for complex protein. As these constitute the muscles, etc., they play a most important role in animal feeding, and while they can in a measure take the place of the non-nitrogenous, the latter cannot play a similar role. The greater their percentage in a fodder, the greater will be the feeding value of the product. At present, it is generally accepted that fat may be formed from albuminoids. Experiments show, that the greater the increase of weight in animal feeding, the greater must be the quantity of albuminoids furnished.

Acidity. The property of being acid, an excess of acid.

Albumin. The white of an egg is composed largely of albumin; it is a proteid and is the main constituent of the body; there are several varieties, their names depending upon their source, such as serum albumin, vegetable albumin.

Alkali. A substance caustic to the taste and which will neutralize acids and blue litmus paper.

Alkaline. Having the properties of or relating to alkali.

Alimentary canal. This taken as a whole includes the stomach, intestines, etc., through which food passes during the process of assimilation.

Alkaloids are vegetable principles having alkaline properties. They do not actively enter into the question of fodders, lupine, however, being an exception.

Amids. Owing to their solubility, amids readily pass through the cells of plant tissues and thus furnish the nitrogenous substance of which they consist; they are oxidized just as are other nutrients.

The determination of amids in fodders is rather complicated, and would take us beyond the general scope of this present writing. During the early history of feeding animals, very little attention was given to amids, yet it was freely admitted that there was some substance in the nitrogenous part of foods that was not protein in the true sense of the term. The experiments of Schultzen and Nencki, etc., appear to show just what role the amides play during assimilation. The conclusion one can draw from the result of their investigations is not entirely satisfactory; however, in the case of asparagin, the resulting gain was pronounced.

Anhydrous means free from water.

Anhydrous sulphuric acid means sulphuric acid free from water.

Ash. If a fodder is burned until the entire organic matter has disappeared, certain precautions are necessary in order that volatilization of the chlorids, etc., may be avoided. The substance or residue remaining is called ash; it is made up mainly of potash, soda, lime, iron, sulphuric, carbonic and phosphoric acids. In certain cases, however, it is found desirable when feeding young animals, to add wood ashes, precipitated chalk and phosphate of lime to the ration. The ash percentage varies very considerably; for example, in pasture grass it is 2.5 per cent., while red clover hay may contain 6.2 per cent. This latter percentage is misleading for various reasons. The ash of beets. beet residuum, etc., varies with the methods of cultivation of the roots and the modes of manufacture at the factory.

As the ash of a fodder is made up of most of the ingredients of the animal's body, it has a very important role to play in feeding in general. Feeding stuffs upon general principles all contain an ample supply of mineral substances—there need be no apprehension of their quantity being deficient. In rational farming, when the fertilizers are judiciously used, the percentage of mineral salts fed to be found subsequently in the excrements is of more than usual importance. Upon general principles, it may be admitted that over 80 per cent. of these salts are found in the solid and liquid excrements. There is excreted in the urine nearly the entire amount of sulphuric acid and chlorin contained in the fodder; while in the case of lime, 2 to 5 per cent. is found in the urine; with magnesia only 0.25 per cent. is thus thrown off.

Asparagin is an alkaloid found in seeds of certain plants, also in asparagus, sugar-beets, etc. It is an amid of aspartic acid.

Assimilation. The terms "assimilation" and "digestion" are very much the same; the process consists in taking up from the feeds the nutrients that may be employed to make up for the wear and tear and form new tissue.

Bacteria is synonymous with microbes; they may be in straight rods or twisted rods, etc., they may be either dependent upon free oxygen, or, as in plants, may appropriate the oxygen of the organic combinations and thus act as a putrefactive agent.

Betain. This substance is a special form of amid; the product contains about 11 per cent. nitrogen; it disappears apparently during the second year's growth of the beet.

Bolus. The food before being swallowed by many animals is arranged by the tongue, etc., into a rounded ball, known as a bolus.

Brewers' grains, on account of the percentage of asparagin they contain, give to milk a flavor very like that noticeable after eating asparagus.

Calcic carbonate is another name for carbonate of lime.

Calcic phosphate is another name for lime phosphate.

Calorie. A unit of heat, being the amount necessary to raise the temperature of one kilogram of water one degree Centigrade. (Or one pound of water 4° F.)

Carbohydrates. These include first the so-called nitrogen-free extracts, such as starch, sugar, gum, etc., second the woody portion of plants. The word carbohydrates indicates that these bodies contain, besides carbon, a certain amount of hydrogen and oxygen, in the proportions in which they combine in water. The first series are readily digested, the second very much less so. Carbohydrates play a very important role in cattle feeding; when fed they are not stored, but are either burned or converted into fat. As they serve the same purpose they are grouped with it, and hence it is customary to multiply the quantity of fat by 2.25, which is then added to the carbohydrates. When carbohydrates are fed alone, they do not appear to affect the protein consumption, consequently their action may be compared with fat as far as their influence on protein is concerned; without food the protein waste is just the same as it is with carbohydrates.

Carbon is a non-metal and occurs in various forms, such as diamond, graphite, etc.

Carbonates. Carbonic acid combines with alkalies to form carbonates.

Carbonate of lime is a substance formed by the combination of lime with carbonic acid.

Carbonatation is one of the operations in beet-sugar manufacture; it has for its object the liberating of the sugar from its combination with lime, by the use of carbonic acid, which forms a precipitate of carbonate of lime, subsequently separated by filtration.

Carbonize. When organic substances are submitted to heat and the volatile substances are driven off, they are carbonized.

Carbonic acid. When carbon is burned in the air, there is formed carbonic acid.

Carnivorous. The flesh-eating animals are known as carnivorous.

Casein is a substance contained in milk; it is not coagulated by boiling, and is separated by precipitation with acids and by rennet at 40° C.

Cellular tissue is composed of rounded cells of plants; the tissue itself is an aggregate of cells which are governed by a law of growth.

Cellulose. Cellulose is made up of 6 parts carbon, 10 parts hydrogen, and 5 parts oxygen, and has the formula $C_6H_{10}O_5$, which makes up the cell tissue of plants in general. Linen that has been frequently washed and is old, is made up of almost pure cellulose. The digestibility of this product was for a long time refuted, but it is now proved that it undergoes a decided fermentation in the paunch of ruminants. During this period, there is formed 33.5 carbonic acid, 5.7 protocarbide of hydrogen, 33.6 acetic acid, and 33.6 butyric acid. If one make allowance for the nourishing value of acetic and butyric acids, it may be concluded that cellulose has a decided nutritive value, and some say that 50 per cent. of the weight may be considered digestible. To determine the insoluble cellulose percentage in a fodder, it is customary in most laboratories to finely divide the product, and to subsequently boil with dilute acid and alkali, this to be thoroughly washed in alcohol and ether; there remains a certain percentage of albuminoids which must be deducted, and what remains is called crude fibre. (See Digestibility.)

Centigrade degrees are equal to 5.9 Fahrenheit degrees, to which are added 32° in converting a Centigrade into a Fahrenheit reading.

Cereal wastes include bran, wheat middlings, etc.

Chlorids. Hydrochloric acid combines with alkalies to form chlorids.

Chlorophyl is the coloring substance contained in all green plants; through its agency carbohydrates are formed.

Chyle is a whitish fluid, accumulated during digestion, and which, when allowed to stand, separates and becomes a substance very like serum.

Clovers offer certain advantages over grasses and hay for they contain nearly twice as much protein as the latter; in other respects the composition is about the same. There are many varieties of clover, the most desirable being the white clover.

Coagulate. To coagulate means the formation of a coagulum or clot.

Coefficient of digestibility and nutritive relations. Upon general principles it may be admitted that the value of a ration depends upon its digestibility.

Wolff, many years since, demonstrated that there is a relation between the amount digested and the actual composition of a fodder. Whatever be the formulæ given, it must not be forgotten that they are only approximate and are to be accepted only as guides in the feeding. There are too many factors in the problem of cattle-feeding to permit a combination that would apply to all cases that might occur. If the more salient ones only are considered, these are more than counterbalanced by those whose influence upon the general laws relating to assimilation there can be no possible means of determining. The problem as it stands consequently consists of a practical and theoretical side, the one based upon observation of the chemist in his laboratory, the other being the results obtained by the breeder on the farm. The farmer has his capital at stake and he is the one to suffer when mistakes are made. Consequently, there can be no doubt that practical observation upon cattle-feeding, which may differ with each individual, has a money value very much greater than is possible to obtain by adhering to any theoretical consideration; however, as far as possible, it is desirable to have a general knowledge of both sides of the question which will permit new fields of investigation with fodders of which a farmer has had no previous experience.

The early formula generally adopted was:

$$\text{C. D.} = \frac{\text{Protein} + \text{Fat} + \text{Nitrogen Free Extract}}{\text{Protein} + \text{Fibre} + \text{Fat} + \text{Nitrogen Free Extract}}$$

$$= \frac{\text{Protein} + \text{Fat} + \text{Nitrogen Free Extract}}{\text{Organic Substances.}}$$

But the organic substances are represented by dry matter less ash. Consequently the formula reads:

$$\text{C. D.} = \frac{\text{Total Protein} + \text{Fat} + \text{Nitrogen Free Extract.}}{\text{Dry matter—Ash.}}$$

If applied to meadow hay for example:

$$\text{C. D.} = \frac{8.5 + 3.0 + 38.3}{85.7 - 6.02} = 0.62$$

Calculations based upon this formula give the following coefficients: hay = 0.60; straw = 0.40; husks = 0.50.

If it is desirable to replace a portion of hay by straw in a ration, owing to special circumstances of the market, the amount of straw to be used may be estimated by considering the coefficient of digestibility of the two fodders, hay (0.60) — straw (0.40) = 0.20, which means that 20 per cent. more straw must be used to get the same effect as would have been realized with $\frac{1}{5}$ less hay. This is an excellent practical example of how a farmer can meet existing conditions. The nutritive relations of a ration should also be considered as it has an important influence; while this may be considered as a relative digestibility, the absolute digestibility depends upon various causes. Between these terms there exist frequent confusions. Two fodders, oats and hay for example, may have the same absolute digestibility, but not the same value for feeding unless their relative digestibility is also the same. The fodder that yields the greatest amount of nutritive elements that are digested, has the highest value. In such cases, it must not be forgotten that feeding stuffs when alone, act very differently than when combined, and may produce a collective depressing effect. The digestibility of the protein of a fodder may decrease by the addition of starch, for example, and remain constant by a further addition of some fatty substance. Hence there has been proposed a special factor known as adipoprotein relation, which is a proportion between the protein and fatty substances. Attention should be called to the fact that the best results are obtained when the proportion is 1 to 2. (In hay it is $\frac{1}{2}$ to 7.) When there is too much fat or too little, the effects are equally bad. When the nutritive relation (relative digestibility) is $\frac{1}{5}$, the best combination then is 1 protein, 0.5 fatty substance and 4.5 carbohydrate. Some authorities maintain that the proportion between fat and protein should never be lower than $\frac{1}{3}$.

In all these formulæ, too little account is taken of the proportion between total dry matter and protein—in reality it has a most important effect upon digestibility; furthermore it permits one to form a very satisfactory idea of the degree of concentration of a fodder. It is frequently maintained that the proportion should be $\frac{1}{10}$ per 100 lbs. live weight, in other words 10 dry matter for 1 protein.

Coloring and volatile substances. Fodders frequently contain certain coloring substances, but as these have very little nutritive value, they are seldom taken into account when estimating the value of a fodder; the same may be said of the volatile oils. However these, upon general principles, may be considered objectionable, as they transmit to milk an unpleasant taste and odor.

Concentrates include grains and mill products. It is a great mistake to use too much concentrated fodder, as there would be danger of bringing about an abnormal fattening. A poor fodder would be the other extreme. (See Digestibility.)

Constituents of the animal's body. The composition of an animal body may be considered either from an organic or a chemical standpoint, the microscope revealing the elementary forms, while the chemical substances may be determined by suitable tests.

The elementary form is the primordial cell; it divides itself into two parts, each of which again becomes two; this segmentation goes on, thus forming the various tissues of which the body of the animal consists. Whatever may be the tissue, it originated from a single cell. In the blood the globules retain their original shape, but in most cases they make up the fibrous tissue. After a tissue has reached its ultimate form, it must be constantly renewed and the burned portions eliminated. The combinations of these cells are very numerous, and the tissues which they form constitute the various organs of the body; among which we have the bony, cartilaginous, conjunctive, muscular, mucous and nervous tissues. The bony tissue forms the skeleton upon which rest the other tissues and organs of the body. The cartilaginous tissues have a certain elasticity. In them are formed the phosphates, carbonates of lime, etc. The stronger bone is not compact, as many suppose, but on the contrary is made up of spaces more or less open, the outer portion being the hardest. The conjunctive tissue is spread over the entire body. Its nature varies with work to be done, covering muscles, or constituting a tissue in which is deposited the fat. When it forms the ligaments of bones it assumes an undulated shape.

The fatty tissue is made up of cells more or less round and filled with fat. Every new formation of fat means an increased number of cells. When fattening is in view it is not alone necessary to feed so as to make fat, but the fodder should also contain those elements which help to build up the cells.

The muscular tissue makes the meat of the body; it is by these that the body receives its power of motion. They are attached to the bones by tendons, the thickness of which varies with the work to be done. It is not necessary to enter into various considerations showing of what muscles consist.

The nervous tissue is the center of all the sensations of the body. All organs receive from the nerves the impulse upon which they enter into activity, and all voluntary and involuntary movements of the body are regulated by the nervous tissues. Every perception of the senses is through the nervous tissue.

Mucous tissue covers all the empty spaces in the interior of the body, the digestive canal, the respiratory organs, etc. Its importance is very great during every stage of the animal's development. A reasonable knowledge of this question should be possessed by every farmer.

The body of an animal consists mainly of nitrogenous elements, besides which there is distributed through the tissues a certain amount of fat and non-nitrogenous substances. After these are burned, there remains a residuum which represents the mineral elements. It is interesting to pass these rapidly in review, remembering that the starting-point in cattle-feeding is to furnish in the fodder those elements of which the body consists, so as to renew the constant waste and build up new tissues. Experiments have long since demonstrated that plants offer advantages not found elsewhere for this purpose. Other experiments in digestion show what variety of plant gives the best result in the physical laboratory of each kind of animal under consideration.

(*a*) Nitrogenous Elements.

The main characteristics of plants is their high percentage of carbon; in animals, on the other hand, the salient characteristic is the nitrogen. With young and thin animals, nitrogenous substances constitute the principal part of the dry matter of the body. The most important group of nitrogenous elements is the albuminoids or protein substances; these are met with under most varied circumstances; they contain about 16 per cent. nitrogen, 7 per cent. hydrogen, 54 per cent. carbon, 22 per cent. oxygen, and 1 per cent. sulphur. They form the principal constituents of blood, eggs, muscular and nervous tissue. When dried in the soluble form, they are white or yellowish, without smell and soluble in water; in the insoluble form they are insoluble in water. By coagulation the soluble portions may be made insoluble.

The most important of the group is albumen, found in all the liquids of the animal's organism, more especially in the chyle and serum, the colorless portions of the blood, and in the juice of meat or muscles.

Fibrin is next in importance in the nitrogenous group; it is found either liquid, dissolved in the blood, or in a solid state in the muscles.

All these protein substances may undergo numerous transformations. It is from them that all the other nitric elements originate, of which the body consists, and in particular the gelatigenous substances. These are next in importance to the albuminoids; they constitute the nitrogenous organic substances of bones, cartilages, the greater portion of the tendons and ligaments. By prolonged boiling these gelatigenous substances are converted into glue; they contain less carbon than the albuminoids, and are entirely free from an organic combination of sulphur—when it exists its percentage is generally less than in the albuminoids; to them belongs a special group known as horny matter; they are found in the outer portions of the body, a thin layer upon the skin, or under different aspects, such as hair, wool, horns, claws, etc. Their composition is about as follows: 51 per cent. carbon, 7 per cent. hydrogen, 16 to 17 per cent. nitrogen, 20 to 22 per cent. oxygen. Consequently, it is interesting to note that the average composition of different parts of the body is very like that of pure albumin. Several important experiments show that the nitrogenous organic matters of the body, other than the albuminoids and horny matter, have but little influence on the percentage of nitrogen of which the body consists.

(*b*) Non-nitrogenous Elements.

These include the carbohydrates and mineral constituents.

Lactic acid is one of the non-nitrogenous organic substances which help to make up the body; it is found in the blood and in the muscular tissues.

It is one of the elements of sugar of milk found in the gastric juice, and also in the small and large intestines.

Sugar is also found in the blood, in a maximum quantity of 0.1 per cent., in the vein leading from the liver in the direction of the heart; on the other hand the liver contains a substance known as glycogen, which is very like sugar, found also in very limited quantities in the muscles of the body; with it is also another substance called inosite, possessing properties and a composition very like sugar. Many substances found in the bile and other secretions of the body are also non-nitrogenous, but their percentage is so small that it is not even necessary to mention them.

Fat is to be found in variable quantities in blood (0.1 to 0.3 per cent.), also in milk, the nerve tissue, etc., in all solid or liquid parts of the body, in special cells under the skin, between the muscles and in the muscular fibres. It is either in solid state like tallow, or in a liquid condition not unlike oil. Its appearance, color and taste vary very considerably with the animal from which it is taken.

The thin membrane forming walls of cells containing fat represents about 0.8 per cent. of total weight of tissue. All fats contain at least 75 per cent. carbon, 11 per cent. hydrogen and 12 per cent. oxygen, and are consequently excellent heat formers. When not consumed, they are deposited in their special cells, where they remain and increase in quantity unless called upon to supply an insufficiency in the fodder used; animals dying from hunger consume almost all the fat of their bodies. Fats take a most important part in assisting the assimilation of protein substances and in the formation and development of animal cells. An interesting fact is that fat found in plants is almost identical with fat found in the body of an animal. Before being deposited, it undergoes certain transformations and may be in greater volume than the fodder used originally contained. The quantity of fat deposited may reach 40 per cent. of the total weight of cattle, or several times more than all the dry nitrogenous substances representing the animal's weight at the time of killing. An animal in perfect condition has rounded proportions due to fat, which in no manner interferes with the general functions of the body; on the other hand when submitted to a process of systematic fattening, the functions of the body are interfered with, and disease may declare itself if continued too long.

Every part of the body contains water in quantities that appear to vary with the age of the animal. Upon general principles it may be admitted that 50 per cent. of the total live weight is water. In newly born animals, this percentage may reach 80 to 85.

While in certain cases bones contain 70 per cent. water, when they attain their full development this percentage is only 20.

The water of the body may be considered as a general solvent; it determines the absorption of the nutritive liquors of the intestines, renders possible a contact between various substances and the organs of the body, and in the daily excretions considerable water is found which has helped to carry off the general wastes of the body.

Of the mineral substances mention may be made of phosphoric acid and lime, which exist in almost equal proportions, and are about equal to $\frac{4}{5}$ of the total weight of the ash residuum after incineration of the body; the rest consists mainly of potassa, soda, magnesia, iron, chlorin, sulphuric acid, carbonic acid, and a small percentage of silica.

Bones are made up mainly of mineral substances. For full-grown animals these represent $\frac{2}{3}$ of their total weight, this percentage varying with the outer, middle and inside parts of the bony frame. About 87 per cent. of the ash from bones is phosphate of lime, the remainder being mainly carbonate of lime. The dried part of bones without fat contains 27 per cent. phosphoric acid, 38 per cent. lime, and 3 to 4 per cent. carbonic acid.

Magnesia plays only a very secondary role in the constitution and the maintenance of animals; its exact functions are almost unknown. Iron is found in quantities representing 0.013 to 0.042 per cent. of the live weight of a full-grown animal in a good condition; its most important functions are in the blood; it is the essential element upon which the coloring of blood depends; its existence is essential to the good health of animals, as shown in the experiments of Hosslin. When not in sufficient quantity, the animals were tired and had a very active circulation, owing to the absence of hæmoglobin. The arterial blood contains oxyhæmoglobin, in which is found 0.45 per cent. iron.

The blood always contains alkalies and a certain percentage of sodic chlorid, so important for the regular working of the functions of nutrition and respiration. They must be constantly renewed so as to assure the proper workings of all organs connected with assimilation.

The functions of potassa appear to be confined to the formation of tissue cells. The weight of potassa and soda combined that should be fed per diem, is 300 grs. per 100 k. live weight. These alkalies are constantly eliminated through the urine, and the fodders must not be deficient in them. In fact, numerous experiments in feeding without mineral salts soon resulted in death, notwithstanding the fact that the body appeared to be in a perfectly healthy condition. The blood and brain lost 10 per cent. of their water under this regimen, and this was followed by a general decrease in phosphoric acid, etc. The fodders for young animals should never be deficient in lime and phosphoric acid, otherwise the bones are weak, and the muscles become flabby. For lambs 2 gr., young swine 3 gr., calves 15 to 18 gr. of lime per diem, and about same quantity of phosphoric acid may be considered good proportions, for the maintenance of the bony tissue. These remarks apply mainly to very young animals; in older cattle, on the other hand, if these salts are not given in suitable amounts, death carries off the animal before the bones have had time to be affected, so that rickets or osteoma must be due to some other cause. Upon general principles it may be said that one need have no apprehension as regards the percentage of salts, as all well-combined rations contain these, and they are, in most cases, in abundance. Sodic chlorid and lime are the most important to be considered. In feeding beet pulp or beets. the phosphoric acid is generally in greater quantities than lime. and an addition of the latter may be found desirable.

Corn and cob meal is becoming of late very popular in cattle feeding, the corn and the cob being crushed to form the meal. There is a considerable amount of this feed sold that is not economical, for the reason that the crushing has not been pushed sufficiently far and there follows considerable waste when fed. Certain advantages, from a digestive standpoint, are claimed for this combination.

Corpuscles, as they exist in the blood, are flat discs. They may be red, white or colorless.

Cotton seed meal. This is a residuum from the manufacture of cotton seed oil, and for over twenty years it has been in very general use in cattle-feeding. Its advantages depend largely upon its protein constituents and the reasonable percentage of fat entering into its composition offers an additional argument in favor of its use. It does not contain carbohydrates (starch, etc.). Under all circumstances when fed, it should be combined with coarser fodders, containing a heavy percentage of carbohydrates. Its main advantage is its cheapness, and in this respect it offers exceptional advantages for making up a ration deficient in protein. When used with certain discretion it will increase the flow of milk, and give special hardness to butter. Four pounds per diem in many cases is not considered an excess. Not more than 2½ lbs. per diem is considered desirable in most cases for 1,000 lbs. live weight. The advantages to be derived from its use are not as great with pigs, sheep and horses, as they are with milch cows. Composition varies from 20 to 50 per cent. protein for 8 to 18.5 per cent. oil. In most cases the meals have a yellow hue, and those in which ground hulls are reasonably absent may be considered the most desirable.

Crude fibre. White crude fibre makes up the walls and cells of plants. It is of a very variable composition; when obtained from hay it may contain 45.5 per cent. of carbon, and when from other sources very much more. There are several substances in combination with it; but from a practical standpoint those are overlooked. The percentage of crude fibre varies very considerably, as beet leaves may contain 2 per cent. of this substance, and salt marsh hay over 30 per cent.

Cubic meter is equivalent to 264.2 gallons.

Defecation. With the view to the purification of beet juices, they are submitted to a liming, which operation is known as defecation.

Desiccation. When organic substances have their moisture removed, they are desiccated; this in other words is drying.

Digestibility.—*Factors governing digestibility.* There are many conditions that affect the digestibility of a fodder. These may be divided into two important classes; on the one hand, the individual characteristics of each animal under observation; on the other, the kind and composition of ration used.

Ruminating animals appear to digest certain forages with exactly the same ease; the variation between the digestive powers of cattle and goats, for example, is so slight that it need not be considered. Comparative experiments with horses are not within the scope of this present writing. What has been said respecting different ruminating animals, applies to species of the same breed, for example, with sheep; Merinos, Southdowns, etc., when stall-fed on clover hay or other fodder digest the same ration in about the same proportion. Wolff says that the digestibility of a fodder is too frequently confounded with its nutritive value. The latter may vary with the breed, as it depends upon the appetite of the animal, which means that the amount of fodder consumed daily depends upon individual characteristics. On the other hand, the digestibility relates to per cent., regardless of the faulty conditions of the animal's digestive functions. Experiments prove that the age of the animal or its degree of development has very little influence (?), the necessary conditions being that they be thoroughly weaned and that the fodder given be suitable for the purpose intended and of an agreeable flavor. Investigations made at Proskau show that these facts are true, even in cases where sheep are two years old. They would not hold good in cases where the fodder is of difficult assimilation, the length of life of an animal then depending upon its powers of digestion, so as to be able to draw sufficient nutrient from fodder for its vital sustenance.

Under these circumstances it is evident that individual characteristics must also be considered. When an animal is young, and full of life, the chances for having a perfect digestion are certainly better than with those more advanced in years whose circulation is more or less active. Experiments coming under the writer's notice appear to prove that nitric elements are more easily digested in very young animals than in those a year old; but as previously said, the difference is very slight. Great differences may be observed in the same animal at different periods of its existence; the variation may be even greater than it is with different animals of same breed. Weike has remarked that in feeding sheep the proportion of organic substances digested may be reduced 7 per cent. and cellulose 15 per cent., as compared with normal conditions.

It is curious to observe that the animal which has the best digestion is not necessarily the one that will most rapidly increase in weight; in other words, the amount of fodder consumed has far greater influence upon the augmentation of adipose tissue than has the coefficient of digestibility. Animals that are stunted or badly fed when young, show the effect of their poorly developed condition by the poor working of their digestive organs.

What was said respecting the digestibility of a fodder taken as a whole, is not entirely true when the components of which it is composed are considered separately. We have for the following coefficients of digestibility of food components for different animals:

COEFFICIENTS OF DIGESTIBILITY FOR FODDER COMPONENTS.

Animals experimented on.	Protein.	Fat.	Nitrogen free extract.	Fibre.
Sheep	0.57	0.61	0.72	0.58
Cows	0.57	0.65	0.70	0.61
Oxen	0.65	0.64	0.66	0.60
Goats	0.60	0.44	0.64	0.62

From which data one might draw the following conclusions: Sheep and cows do not utilize the protein as advantageously as oxen and goats; they, however, assimilate better the nitrogen free extract than do the animals last mentioned. The influence of work upon digestion is a very important factor too frequently overlooked. Experiments have been made upon horses showing that the coefficient of digestibility was almost entirely independent of work done. In other words, when a horse did "A" foot pounds of work per diem the proportion of organic substances digested in the ration was exactly the same as when the animal did "2 A" foot pounds during the same interval. What applies to organic substances applies also to protein, cellulose, nitrogen free extract, etc. The amount digested of these remains the same whatever, within reasonable limits, be the work done. Just how far this would apply to oxen, and other farm animals that may be employed for their muscular power we are unable to say. The influence of the composition and kind of ration used upon its digestibility is made very evident when we consider that the function of digestion depends upon the extent to which the gastric juice acts upon the molecules of each element of which the ration is composed.

This coefficient must necessarily vary, not only with each plant, but also with the same plant, depending upon its age, method of harvesting and keeping. What has been said in regard to plants, refers more particularly to coarse fodders; the by-fodders used and their composition have also an important influence not to be overlooked. If the ration varies in weight from day to day, the per cent. of digestibility of each of its components remains constant. Wolff's experiments at Hohenheim and elsewhere demonstrated beyond cavil that this is almost mathematically correct. The animals experimented with were fed on hay.

A fact now generally admitted is that cattle in general, when in a good healthy condition, will eat the amount of fodder per diem that their requirements may demand; but it is not admissible that, by reducing the value of a ration, a greater assimilation can be realized. The coefficient of digestibility remains constant whether one, two or three pounds of clover hay are fed to sheep per diem without addition of other fodders. All these experiments are very limited and the conclusions obtained are to be accepted only with a certain reserve.

It is admitted that every element is digested in the same manner regardless of the condition in which it is furnished, whether in a dry or fresh state. At first this seems to be a paradox, but can not be doubted, as it agrees with practical tests made under most varied conditions. An essential requisite is that the fresh and dried fodders be exactly of the same composition. While such results may be obtained with fresh or dried beet cossettes, with coarse fodders it is almost impossible to realize them, as the method of harvesting and drying may have great influence. The exact influence that the water of a fodder has upon milk, is still an open question. Whether water added to dry cossettes, for example, produces the same effect as the water contained in sliced beets, experiments have not yet been made in sufficient number to determine. The method of storing coarse fodders has considerable influence on their digestibility. Experiments upon hay show that 62 per cent. of its protein was digested when used, after being recently harvested; only 54 per cent. was digested three months later, while the digestibility of crude fibre and nitrogen-free extract remained almost constant. The great losses attributed to coarse fodders are frequently due to there having been some neglect in siloing. The period of development of a plant has considerable influence on its digestibility; if fed during the first period the fibre is very tender and is almost entirely assimilated. Seventy-one per cent. of protein of green clover, cut before flowering, when fed to an ox was digested, while several months later only 40 per cent. was digested. The early cut fodders contain a much smaller percentage of protein than is found later, which is another explanation of its increased digestibility. To these conditions must be added the influence of climate, soil, fertilizer, etc. Method of preparing a fodder has an important influence upon its digestibility—cooking, maceration, etc., may give good results in special ways. Hellriegel and Lucanus, by a series of experiments, demonstrated that straw that had been fermented and fed to animals underwent no variation in its coefficient of digestibility. With hay the digestibility of cellulose was slightly increased, while on the other hand, the digestibility of nitrogen-free extract was lessened. Just why this should be the case is not stated. There can be no doubt that the palatability of a fodder may be increased by judicious preparation, under which circumstance animals eat very much more than they would have done had the special preparation not been resorted to. Consequently, satisfactory results may be thus obtained, notwithstanding the fact that the percentage of nutrients assimilated would be only to a limited extent increased. What has been said of coarse fodders, applies equally to concentrated fodders. Kühn and Mockern have shown this to be the case by feeding to oxen acidulated bran, that had been previously saturated in hot water, whereby the digestibility of its protein had decreased. By heating bran with alkalies, very much the same result was obtained.

Concentrated feeds; their influence upon digestion. As has been previously pointed out, various conditions, such as age, method of harvesting and keeping, etc., of coarse fodders, influence their digestibility, and concentrated or by-fodders added to make up the ration, must also be considered. The digestibility of these when fed alone, is not the same as when commingled with hay, etc. A fact to be constantly remembered, is that while in some cases the by-fodder may help the digestion of coarse fodders, if not properly used the effect will be depressing. To fully determine the influence of a by-fodder upon digestion, it should be added in increasing quantities to a ration, so that, knowing the digestibility of the compound considered as a whole, and also that of the coarse fodder separately, by subtraction an idea may be had of the influence of this fodder. These results are not very accurate, but are sufficiently so for the calculation of rations. If in the various experiments made the same coefficient of digestibility is obtained, it would give the digestibility of the by-fodder added; if changes have occurred, the difference of digestibility would show what the depressing effect had been. In all these experiments it is supposed that the digestibility of hay has remained unaltered. In all such experiments, it must be understood that the coefficient of digestibility means the result obtained by dividing the digestible protein by the carbohydrates, including digestible crude fat reduced to its equivalent of starch by the factor 2.25. Experiments of Schulze and Maercker show that the addition of albuminoids to a ration has no depressing effect. These experiments were upon sheep that received 2.2 lbs. of hay per diem, to which were added 120 grams wheat gluten containing 78 per cent. albumin; in the second series 262 grams of gluten were added.

The proportion of digested protein of hay remained almost unchanged; the difference noticed may be ignored in view of the fact that some of it was not entirely assimilated; for crude fibre, etc., the depression was very slight, the difference becoming even smaller when the whole ration was considered.

It may consequently be concluded that gluten is almost entirely digested, and that albuminoids, taken as a whole, have very little influence upon the digestibility of a fodder. It is interesting to examine the influence of nitrogenous by-fodders, where the coefficient varies from 1–1 to 1–5. These have very little influence upon the by-fodders to which they may be added. Experiments in sheep, goat and oxen feeding were made with rape, cake, bean, cotton seed. meal, crushed beans, etc. Other by-fodders, such as oil cake, distillers' residuum, etc., would lead to the same results. It is important to understand that in these concentrated fodders each element has its own special digestibility that remains nearly the same, notwithstanding the percentage of these used in the ration. For example, 90 per cent. of the protein substances of peas and other vegetables of the same class may be digested by ruminating animals, 85 per cent. when in flax oil cake, etc. On the other hand, the proportion of digestible protein of coarse fodders remains nearly the same when fed alone or in conjunction with other fodders. The influence of grains (nutritive relation 1–5 to 8) has not been examined as thoroughly as the importance of the subject demands. The experiments of Hofmeister and Haubuer may be cited: The proportions between hay and oats fed varied from 1–1.76 to 1–3.30; about 78 per cent. of the protein of oats was digested.

Numerous experiments lead one to conclude that when the nutritive relation is 1–5.5 there is no depression in the digestion of a coarse fodder eaten at the same time as the concentrated by-fodder. When the digestibility is made 1–8 to 10, the digestibility of coarse fodder decreases.

Digestibility of crude protein. The digestibility of crude protein in a fodder depends upon the kind considered, reaching 80 per cent. in some cases. In good hay the digestibility of protein seems to depend upon the proportion between it and the organic substances, while cellulose also takes an active part, and has an important influence upon the result. Many formulæ have been proposed, having for their object the mathematical determination of the digestibility of a fodder. As the results depend upon the percentage of protein, their accuracy rests upon a series of practical experiments giving averages; the coefficient can then be used to a great advantage. If we admit the theory of a partial fermentation in the intestinal canal as was supposed in discussing the digestibility of cellulose, it must not be forgotten that there would follow a loss of protein. Tappeimer estimates this to be 10 per cent., which cannot be accounted for; but as regards this assertion, nothing is certain, as the loss may be only apparent, for Kirschner's experiments appear to prove that this loss largely depends upon the percentage of carbohydrates in the fodder. When these are in excess, they prevent the fermentation of protein in the intestinal tube. Before giving some interesting examples of experiments having in view the digestibility of protein and formulæ relating to same, it is well to point out their weak side, which is that they are solely based upon chemical transformations and no allowance is made for the physical characteristics, which are variable and must be considered in each special case. The experiments having in view the determination of the digestibility of protein have become so numerous that an average of a few hundred of them gives a coefficient that may be considered mathematically correct.

Some important observations to determine the influence of pepsin upon the digestibility of protein, were conducted under the auspices of Stutzer, later by Pfeiffer. The fodder was first treated by an acid solution of pepsin, then by an alkaline extract of pancreatic fluid; excrements were also treated in very much the same manner. The results obtained were almost identical with those of the natural digestion of sheep. In five experiments, the fodder used varied in each case, 1st meadow hay, 2d meadow hay and oil cake, 3d same as second but dried diffusion cossettes added, 4th clover hay, 5th clover hay, oil cake and diffusion cossettes fresh. If 100 represents the total protein in each case, the following proportions of crude protein of the ration were not dissolved or digested:

	1st.	2d.	3d.	4th.	5th.
Artificial digestion ...	20.57 %.	14.41 %.	13.22 %.	10.83 %.	10.69 %.
Natural digestion	21.46 %.	15.4 %.	13.65 %.	11.32 %.	9.93 %.

The proportions would be much higher if no allowance were made for the nitrogen furnished by the body during assimilation. Kellner's experiments show that for every 100 parts of dry digested substances, there is at least ½ part of nitrogen furnished by the body, etc. As the number of comparative experiments between natural and artificial digestion is very limited, it would be a mistake to attach too much importance to any of them or to abandon existing coefficients of digestibility to adopt those based upon artificial digestion.

A fact to be borne constantly in mind is that the digestibility of protein is the most important question relating to cattle feeding; on it success depends. However, even when these nitrogenous substances are not digested, they are not entirely lost, as they are subsequently used upon the soil as fertilizers. The plant laboratory does slowly what might have been accomplished rapidly in the stomach. A complete assimilation is doubly advantageous to the farmer, as more meat is produced on the one hand, and on the other the nitric elements in the fertilizers are nearly the same as they would have been had they contained protein in excess. In the latter case it is taken up slowly by the plant in growing, while when in a more soluble form, such as urea, the absorption is almost immediate. Numerous investigators, Henneberg, Kuhn, Schultze, etc., have demonstrated that when the digestive ratio diminishes, the coefficient of digestibility of protein decreases. The use of so-called nutritive equivalents based upon their percentage of nitrogen is not accepted by all authorities. Stohmann's experiments point to the fact that it is possible to admit a formula having a variable factor so as to make allowances for each special case, the value of which should be based upon practical experiments.

The Stohmann formula now generally accepted was not the first; and many more recent ones are very satisfactory and give results that are sufficiently correct for most practical purposes.

$$\text{Coefficient of digestibility of protein} = \frac{\text{Fats} + \text{Nitrogen free extract}}{\text{Protein} + \text{Carbohydrates.}}$$

Digestibility of carbohydrates. As previously mentioned, carbohydrates have a decided influence on the digestibility of feeds, upon protein and crude fibre substances especially. In the experiments of Stutzer and Isbert to determine the artificial digestion of carbohydrates without fat, it is shown that they may be dissociated by the action of ferments into two parts, one of which is digestible and the other indigestible. Here again the results in artificial digestion must not be confounded with those of digestion under normal conditions; in the latter there is a series of micro-organisms which have an important influence and may in a measure dissolve the carbohydrates to a greater extent than would have been possible by the action of ferments considered alone. Attention is called to the importance of undertaking some new experiments in this direction, to determine the actual percentage of carbohydrates that is soluble; this being known, the digestibility of crude fibre could be entirely ignored. Wolff discussing the subject, says that no data can possibly be accepted unless shown to be true by practical experiments upon living animals. Of all the carbohydrates having the greatest influence upon digestion, *starch* heads the list. Numerous experiments upon every kind of animal have demonstrated that when its proportion in coarse fodder is higher than 10 per cent. of the dry matter, the influence is noticeable; when reaching 15 per cent., the effect is slight, but is very great when it attains 25 to 30 per cent. In the experiments of Schulze and Maercker, 800 grams of meadow hay were fed with 230 grams of starch; the digestibility of hay fell from 54 to 32 per cent., or a loss of 41 per cent. of the digestible proportion. Consequently, upon general principles, it may be admitted that by the addition of starch in quantities representing ⅙ of the total dry substances of a coarser fodder, there is a depression of 15 per cent. in the digestibility of crude protein and at least 25 per cent. for ¼ starch, and 40 per cent. when the starch is ⅓ of the weight of dry substances. These results depend upon the age and kind of fodder; if a by-fodder consisting mainly of oil cake be added in sufficient quantities, the effect of starch may be entirely neutralized.

Sugar has very much the same effect as starch, but to a much smaller extent. Starch and sugar have a secondary effect upon the digestibility of nitrogen-free extract and fat, so long as the by-fodder is digested, which occurs when the fodder is poor in nitrogen as compared with non-nitrogenous substances.

The feeding of sugar to animals in some countries is a very general practice, not always in the form of pure sugar, but as molasses containing 50 per cent. sugar. Starch on the other hand is seldom used, unless it be in the residuum from starch factories or in potatoes. Roots contain percentages of sugar that depend upon their variety. However, it must not be forgotten that starch and sugar when presented in this shape, have a very different action than when fed alone, due to the fact that they have other elements in combination, among which may be mentioned protein.

It is desired to call attention to some interesting experiments made by Wolff, the results of which are given in the following table. The roots added to the fodders are supposed to be entirely digestible, and the depression noticed refers to other fodders making up the ration. Whether roots are wholly digested or not, does not influence the results obtained. It was noticed that as the quantity of roots used increased, so did the depression in the assimilation of the various elements of which the fodder is composed. In the table herewith the quantities given refer to dry substances of by-fodder as compared with coarse fodder.

VARYING DIGESTIBILITY OF COARSE FODDER WHEN FED WITH ROOTS.

Proportion between roots and coarse fodder.	Crude protein.	Nitrogen free extract.	Crude fibre.	Organic substances.
	Parts of coarse fodder undigested.			
1/6	5	3	4	4
1/4 to 1/3	10	5	7	6
1/2	15	7	10	9
1/3 to 1	25	10	14	12

It has been noticed that potatoes have a very much greater depressing effect than beets for example, but this was more especially noticeable when a large amount was used. The depression was the greatest when the nutritive ratio was the narrowest. One may take these facts into consideration when calculating the components for a ration.

Experiments made do not prove that beets when entering a ration affect its digestibility according to any ratio that may be determined in advance. Upon general principles, it may be admitted that fodders rich in amides introduce carbohydrates or nitrogen-free extract into the ration, under which circumstances their coefficient of digestibility is very high. Experiments made in feeding beets to sheep show it to be 90 to 95; as for the pig, his digestive organs are much better adapted to potatoes than beets.

When considering these experiments, they must be looked at as a whole and not in detail, and the safest rule is to rely upon excess rather than a deficiency, especially of protein. For this reason, the writer has constantly recommended that in feeding beets and pulps to cattle care be taken to add not only sufficient straw, but also a reasonable amount of oil cake.

Digestibility of fatty substances. In most works upon cattle feeding, too little importance is given to the digestibility of fatty substances. The ether extracts, properly speaking, are more or less digestible, but too much reliance should not be placed upon these; for example chlorophyl or the coloring matter of plants is soluble in ether, but yet is not digestible. The same may be said of wax and rosins, so that the digestibility of crude fat (ether extract) depends upon various circumstances which are largely influenced by the special fodder. Sixty per cent. of the fatty substance of fresh clover is digestible, while in certain straws only 35 per cent. can be utilized.

The importance of using a by-fodder containing oil has been appreciated for centuries. The experiments of Crusius have long since demonstrated that fatty substances increase the digestibility of protein and carbohydrates. However, on this question opinions differ. Straw can certainly be better utilized by the addition of fat to a fodder. It is important to use fatty substances in moderation, otherwise ruminating animals soon lose their appetites; this is more particularly the case when oil is added to a fodder, and is not true to the same extent when the crude fat of a by-fodder is considered. Some German experiments prove that 100 grams per diem may be fed without influencing the weight of an animal one way or the other.

The best proportion between fats and protein is claimed by some to be

$$\frac{\text{Fats}}{\text{Protein}} = \frac{1}{2.2} \text{ or } \frac{1}{3}$$

Experiments appear to show that beyond 1–2.2 the fats simply pass into the excrements without being utilized.

Crusius's experiments appear to show almost conclusively that the increase in weight of a sucking calf does not depend upon the protein or milk sugar, but upon the butter contained in the milk of the mother. This should be about 5 per cent. of total milk drunk.

Henneberg and Stohmann's experiments also show that the crude fatty substances contained in a coarse fodder are not equally digestible in all fodders, and that it is not well to assume that more than 1–3 is assimilated; the amount to be added consequently increases with the quantity of concentrated fodders used in a ration.

Investigations relating to the digestibility of fats are not as accurate as those upon albuminoids. Several sources of error constantly occur, due to the fat found in excrements that comes from the bile, which, if not deducted, would lead to the supposition that the fat was less digestible than it actually is. This source of error is slight when the fodder contains considerable fat, but is great when the original percentage was low.

Digestibility of fibre. To estimate the amount of cellulose digested is more difficult than one might suppose. If the percentage of crude fibre found in the fodder fed and excrement obtained be reduced to pure cellulose and lignin, based upon their percentage of carbon, and one result subtracted from the other, the amount obtained representing digestibility would be much higher than the reality. However, from a practical point of view this method answers every purpose. The most important investigations relating to digestibility of cellulose are those of Henneberg and Stohmann. It has been concluded that 30 to 70 per cent. of crude fibre is digestible, depending upon the animal and manner of feeding. Pure cellulose contains about 44 per cent. of carbon or about the same as starch, and it is mainly in this state that it is assimilated. Owing to the excessive length of their intestinal canal ruminants have a special facility for digesting crude cellulose. In the experiments mentioned in the foregoing, in which it was found that oat straw had a coefficient of digestibility of 0.44, wheat straw 0.39, clover hay 0.67, etc., the protein had an important influence. Weiske's experiments upon sheep appear to show that the cellulose dissolved during the last stages of digestion had very little effect towards economizing albumin during the process of assimilation.

There are numerous theorics attempting to prove that cellulose undergoes a partial fermentation in the intestinal canal, during which period there is the generation of marsh gas. One fact is certain, and numerous figures could be given proving such to be the case—it is mainly pure cellulose that is digested and only a small portion of the crude cellulose. Any theory respecting transformation of cellulose during passage through the intestinal canal would apply to other fodders that are difficult of assimilation.

The digestibility of cellulose may be calculated by the Wolff formula:

$$\text{Digestibility of C.} = \frac{\text{Crude fibre}}{\text{Protein} + \text{fat and nitrogen-free extract}}$$

Some recommend the Mehlin formula:

$$\text{Digestibility of C.} = \tfrac{4}{7} \times \frac{\text{Fat} + \text{nitrogen-free extract} - \text{protein}}{\text{Crude fibre.}}$$

The results obtained by estimating with these two formulæ are not the same.

A part of the nitrogen-free extract of a fodder may be considered indigestible and is thrown out in the excrements.

Mehlin says that the coefficient of digestibility of nitrogen-free extract may be calculated by the formula:

$$\text{Digestibility of nitrogen-free extract} = \frac{2\ \text{Protein} + \text{Lignin}}{3\ \text{Crude fibre.}}$$

As a general thing starch and sugar may be considered digestible; notwithstanding this fact however, a certain amount of them is found in the excrements when fed in excess.

It is maintained that there is a sort of compensation between the crude cellulose that is digested and the nitrogen-free extract that escapes digestion; consequently it is admitted that the amount of nitrogen-free extract found in the excrement represents the digested crude fibre and nitrogen-free extract, or in other words, the digested non-nitrogenous matter exclusive of fat.

The results obtained in this direction are very misleading, as it frequently happens that the nitrogen-free extract in the dung is higher than could be theoretically possible.

The sum of digested nitrogen-free extract and crude fibre is equal to the total nitrogen-free extract and fat.

RELATION BETWEEN DIGESTIBILITY OF NITROGEN-FREE EXTRACT, CRUDE FIBRE AND FAT.

KIND OF FODDER.	DIGESTED.		Total.	DIGESTED.
	Crude fibre.	Nitrogen-free extract.		Nitrogen-free extract + fat.
Oat straw	3.790	3.215	7.005	7.245
Wheat straw	1.685	1.085	2.770	2 775
Clover hay	5.140	11.490	16.630	17.265
Meadow hay	3.695	6.965	10.685	10.460

The younger the plant, the more readily is its cellulose digested; as the percentage of crude cellulose is then at a minimum, the digested proportion of non-nitrogenous substances is consequently greater.

In the experiments of Hohenheim with clover of different ages, many interesting facts are demonstrated beyond cavil. If R is the quotient obtained by dividing the digested non-nitrogenous substances by the nitrogen-free extract, determined by analysis of the fodder, and C the percentage of crude fibre digested, we have the following. The age of the clover depended upon the stage of the experiment.

DIGESTIBILITY OF CRUDE CELLULOSE IN CLOVER.

	1	2	3	4
R	111.9	105.5	101.8	88.5
C	60.0	53.	49.6	38.8

From these experiments, it is concluded that the digestibility of crude cellulose diminishes more rapidly than all the non-nitrogenous substances taken together, but is to a certain extent influenced by the percentage of crude cellulose present, which shows that the theory of compensation mentioned in the foregoing is not absolutely accurate.

It is admitted that, with the exception of fat, all the digested non-nitrogenous substances of a fodder are transformed into sugar or some saccharine substance, and that it is assimilated in this form. Consequently from a practical point of view, we may admit that the mass of non-nitrogenous substances of a fodder are simply assimilated as if they were carbohydrates and fat. The nitrogen-free extract that has remained undigested has a composition very like lignin (55 to 56 per cent. carbon) and is of secondary importance.

It is interesting to call attention to Weende's experiments upon sheep and oxen in which it is demonstrated that what is known as water extract, or total solid matter that may be extracted from a fodder by boiling water, gives us an excellent idea of the percentage of nitrogen-free extract that may be digested.

Stohmann's experiments in this same direction gave the following results:

DIGESTIBILITY OF NITROGEN-FREE EXTRACT AS DETERMINED BY WATER EXTRACTION.

KIND OF FODDER.	Substances soluble in hot water.	Nitrogen-free extract digested.	Error.
Oat straw................	3.25	3.17	+ 0.08
Wheat straw..............	0.94	1.07	— 0.13
Clover hay	11.24	11.30	— 0.06
Meadow hay..............	6.42	6.36	0.46

Even in this case important variations are noticeable. This method has never received a general application for the reason that no known proportion exists between the digested portion of the nitrogen-free extract of a fodder and the substances of a fodder soluble in water, the latter containing not only non-nitrogenous substances, but also albumin and ash. This method has, however, a certain practical utility, as the digestibility of coarse and green fodders is in direct ratio to the percentage of solid matter that may be extracted by boiling water.

Digestibility of phosphoric acid. In some special cases, the addition of a lime phosphate to a fodder may render excellent services; it may be essential to secure a complete nutritive effect, notwithstanding the fact that the digestibility of the fodder considered as a whole has undergone very little change. In case of young cattle this is especially important in certain districts where soils are deficient in phosphoric acid, as the crops also suffer in this direction and a lime phosphate should be added to rations of full-grown animals. Many experiments prove that the calcic phosphate is assimilated in the intestinal canal and supplies the deficiency when needed. When coarse fodders are fed alone, very little phosphoric acid is found in the urine. When feeding milch cows the phosphoric acid is especially important; in this, as in other cases if more is fed than is needed, the excess is thrown out in the excrement. An interesting fact relating to this question is that the urine of carnivora and herbivora is identical when they are fed on milk or when starved and compelled to live on their own substance. This fact shows almost beyond cavil that when there is a difference it must be attributed to the ration used. The percentage of lime entering a ration has also an important influence upon the phosphoric acid found in the urine, for the reason that phosphates are formed and are either assimilated or rejected as the case may be. When feeding beets in some special cases, calcic phosphate may be replaced by calcic carbonate.

Digestibility of salt. In discussing fodders in general the importance of salt was pointed out, and at present it is well to say that sodic chlorid is more of a condiment than an actual food, as it stimulates the organs by indirect means and thus increases the digestibility of other fodders. From the experiments of Salzmünde, it may be concluded that the action of salt is very variable; sometimes it appears to favor digestion, and then again it has a retarding action. It is a mistake, from a fattening point of view, to confound the advantages to be derived from forcing consumption of fodders by exciting the appetite, with what occurs when the weight of an animal is augmented by a complete digestion and consequent assimilation of the food furnished, as an animal may consume more than it can assimilate and throw out the surplus in excrements.

Digestibility of ash. Potassa of fodders does not appear to be utilized during digestion, as shown by the fact that 95 to 97 per cent. is found in the excrements. The advantages of potassic phosphate do not come within the scope of this present writing as they refer to swine feeding with special meat compounds. Magnesia is partly utilized; just how, remains to be demonstrated. As a general thing 20 to 30 per cent. of the total magnesia of a fodder is found in the excrement, while of lime 95 per cent. is utilized, leaving but 5 per cent. in excrement. Sulphuric acid and chlorin apparently take no part in the assimilation of the body, and what applies to them may be said of all other mineral elements, etc., which the fodder contains.

These facts should be sufficient to convince the farmers of the importance of carefully collecting both liquid and solid excrements for use upon the soil as fertilizers. It is too frequently maintained that beets, for example, exhaust the soil, forgetting that by proper rotation of crops and fertilizer utilization, the fertility may be indefinitely maintained.

Digestion.—*Cattle in general.* The main object of digestion is to bring about an assimilation which is necessary to build up the wastes of the body. The blood being the principal distributor, the liquids or solids to be utilized must pass by osmosis through the membranes of the various organs in which they are received. The principle of osmosis enables the crystalloids to move through the tissue while the colloids or gum-like substances cannot pass. It is important to note that the passage in question depends upon the nature of the substance. In some cases no transformation need be effected; in others chemical combinations are necessary. These modifications, taken as a whole, are what we call digestion. It is important not to confound laboratory chemical changes with those of the many digestive processes. The entire transformations of what might be called digestive chemistry, are very different from what is admitted as being true chemistry as now taught in the text books, and considerable confusion might arise if the two were not separately considered. Digestion taken as a whole depends upon the mouth, gullet, stomach, small and large intestines, and the several secretions. In the mouth, the lips, teeth and tongue, all have special functions. Farm animals when living under natural conditions, are compelled to hunt for their food; they thus take more exercise and develop more muscle than when stall-fed. Ruminating animals draw up their food with their tongue, which always has a rough surface; the shape of their lips and teeth is such as to offer but little assistance in collecting food. Horses on the other hand use their lips and with the assistance of the incisor teeth on the lower jaw cut the grass or herbs found in pasturage. Cattle when using their tongue give their heads a swinging motion which breaks the tuft of grass held by the tongue and pressed against the lips. The nutrient thus collected is crushed by the teeth on the lower jaw against the hard bone-like substance of the upper maxillary. The cheeks help considerably in either passing the semi-crushed or ground product from one side to another, or holding it during mastication.

It is to be noted that in nearly all the herbivorous animals the lower jaw is much smaller than the upper. It frequently happens that when one side is working, the other is separated nearly an inch. On the other hand, sheep-grazing means that the field is eaten almost to the surface of the ground; the horse is more wasteful, and cattle still more so. In the mouth the various salivary glands secrete special fluids of different consistency and composition, which each have special functions to fulfill; taken collectively they are known as saliva, and contain about 1 per cent. solid matter.

The saliva proper consists mainly of water; besides mucus, it contains albumin, alkaline carbonates, alkaline chlorids, alkaline phosphates, and a substance known as ptyalin, a ferment having a very important function to fill, which consists in converting starch into sugar, a transformation that occurs mainly in the stomach in presence of other secretions. After mastication, the food is soon shaped into a rounded mass or bolus,* which form allows its passage into the throat with the least possible difficulty. The time or duration of mastication, varies with the animal; practical experiments appear to show that a horse needs one and a half hours to masticate four pounds of hay, during which interval there will be formed about sixty boluses. The horse in its normal state can bring its teeth together some seventy times per minute, when there is an ample flow of saliva. The periods change, and Colin's experiments show that when all the saliva is allowed to pour into the mouth, the duration of mastication for one bolus is about 32 seconds; if only one of the parotid glands is open, the duration is 34 seconds, and with both closed, the period is about 75 seconds. During these periods the number of strokes of the teeth vary from 38 to 74. It is not necessary to give similar examples for other animals. For the horse it was found that the saliva secretion amounted to about 12 lbs. of saliva per hour during hay feeding; with green food about half its weight of saliva is needed.

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* The size of a bolus varies with the animal; for an ox it is twice the size that it is for a horse.

Foods after being partly masticated, pass into the gullet and fall into the paunch; here they remain for a reasonable time, and soften in contact with saliva swallowed; those portions that are dissolved pass through into the second stomach (recticulum), then into a third and fourth stomach (*manifolds* and rennet). The coarser portions that have not been sufficiently masticated remain in the recticulum where they collect into a boll shape, when by special contraction of the esophagean canal they return into the mouth and are again masticated and mixed with saliva; when this operation is completed, this food passes again through the esophagus into the third stomach or *manifolds;* by a special arrangement of muscles it cannot again return to the mouth; from the manifolds it reaches the fourth stomach (rennet). In perfectly matured animals the liquids all fall into the paunch where they remain but a short time. Before a calf is weaned, the food passes into the rennet without undergoing the preliminary stages that occur later; in fact the first three stomachs remain during this early stage in an almost embryonic condition.

This process continues until the paunch is almost entirely empty. Between meals the emptying does not seem to be ever complete, as is made evident by the fact that in the excrement of cows one finds a mixture of the ration being fed and the one previously used. As pointed out elsewhere in this writing, four or five days frequently elapse before any fodder is completely eliminated from the system.

Colin cites an example of a cow having fasted for two days and still having over 140 lbs. of dry fodder in the several compartments of its stomach. From the time the bolus enters the stomach, it is kept in constant motion, being more and more salivated with a fluid known as gastric juice. The total volume of this fluid secreted during twenty-four hours is enormous, and some authorities assert that it may reach one-fourth of the weight of the body. It contains water in considerable proportion, also special ferments, chlorids of sodium, potassium, calcium, and ammonia, also hydrochloric acid, ferric and magnesium phosphate. The principal ferment is pepsin, which depends upon a diluted acid for its action upon foods. The main function of gastric juices is that of converting albuminoids into peptones.

After leaving the fourth stomach, the food passes into the small intestine, where it comes in contact with very important secretions, such as bile and pancreatic juice. The bile is green in color, gives an alkaline or neutral reaction and is secreted by the liver. Its composition varies with the animal; beside water and solids, it contains certain salts, lecithin and cholesterin, fats, mucin and coloring substances, also inorganic salts. An ox, according to Colin, will throw out 5.7 lbs. of bile per diem, while a horse secretes 13 lbs.; there is a continued flow during the passage of the food through the intestines. The principal function of .bile is that of aiding in the absorption of fats; some of the fat is transformed into glycerin and fatty acids. There follows a soap formation due to their combination with the alkalies of the bile; this soap helps the passage through the membranes of the intestines which assists in assimilation. Through the intervention of bile, food does not decompose during its passage through the intestines. There is another fluid also of very great importance, which is the pancreatic juice; it is, as its name implies, secreted by the pancreas and enters the intestines jointly with the bile. These two secretions by their combination have some role to fill which they cannot accomplish when acting separately. The pancreatic fluid like the ptyalin of saliva helps to convert starch into sugar; one gram is said to be sufficient to convert 40 kilos of starch into sugar. The pancreatic juice converts fat into salty acids and glycerin, and will change albuminoids into peptones; it will effect this transformation even in an alkaline solution.

Food, during its passage through the intestine, undergoes an absorption or osmotic action. The small intestines are lined with protruding particles, called "villi," whose role is to separate from the fluids, with which they come into contact, the fat, sugar, peptones and salts; these are forced to pass through the ducts of the lymphatic system. The fluid thus formed is known as chyle, and, owing to the fat held in solution, it has a milk-like appearance.

During all these chemical and physical transformations, considerable interchange occurs of which we know comparatively little. Besides the fluids mentioned which act upon foods during their passage through the intestinal canal, there are other secretions helping assimilation; for example, in the small intestine there is a special gland secretion which like the active principle of saliva will convert starch into sugar. As food progresses along the intestinal canal, its nutritive value becomes less and less, and when reaching the second half of the large intestine it is almost an excrement, its color depending upon the kind of fodder and the condition of the bile at the time of feeding. Upon general principles, we may admit that the large intestine of cattle in general serves as a storage during the passage of the fodder not entirely assimilated; there follows in the large intestine a sort of digestion due to the fermentation of cellulose which had thus far not been dissolved by the action of the digestive juices. In conclusion, it is to be said that all fodders are not equally acted upon by the gastric juice. In cereals, if the starch cells have not been thoroughly broken, they pass through the intestinal canal almost untouched. In order to get a satisfactory assimilation in feeding, it is desirable that the quantity of dry substance used correspond to that actually needed by the animal; it can vary from 30 to 70 lbs. per diem for a full grown ox. The organs of digestion may increase or decrease their capacity as the occasion may demand. Without doubt, the best results are obtained by feeding a uniform ration. The condition of digestion may constantly be ascertained by the analysis of excrement.

Diffusion. Modern beet-sugar factories extract the sugar from beet slices by diffusion in an apparatus, called a battery, each compartment of which is termed a diffusor; hot water circulates from one diffusor to the other, and the sugar passes from the cells of the tissues into the circulating water by a physical action known as osmatic diffusion.

Dried cossettes. The pressed residuum cossettes may be submitted to a special drying, the product obtained being known as dried cossettes.

Dry matter. When a substance has been satisfactorily desiccated by heat, there remains what is known as dry matter.

Energy. The capacity of doing work; the power of an organism.

Ether extract. In most text books, the ether extract is called "fat." Its estimation is very simple, consisting in drying the fodder and adding ether which will dissolve the fat and like substances. Its percentage varies very considerably in plants in general.

Fatty substances. The fatty substances are those which may be dissolved from feeding stuffs with ether, and necessarily include coloring matter, wax, etc. The fat is assimilated and burned to form heat and consequently energy, or it is stored up and deposited as fat when taken in excess.

During the fat combustion the heat of the animal's body is supplied. An exertion of any kind is followed by fat burning, just as fuel is burned under a boiler. Fat necessarily plays a very important role during fattening of live stock as it accumulates in different parts of the body, gives it weight and increases its value from a butcher's standpoint. It is to be noted that only a small percentage of the fat enters the blood vessels forming part of the intestines, the larger portion passing through the lymphatics. While it is generally admitted that fats undergo very little change when forming part of the circulation, the fact nevertheless remains that the role they subsequently play in the tissues varies with the animal fed.

Experiments have been made to determine the heat units of feeds, and those relating to fat are of an exceptional interest. For this purpose a calorimeter is used, the substance to be tested is burned therein, and the heat given off is absorbed by water. Prof. Rübner's experiments show that 235 parts of lean meat, when burned in the apparatus, give off the same heat as 100 parts of fat. A gram of fat is shown to yield over twice the calories yielded by a gram of carbohydrates; for feeding purposes it is found that they are equally valuable as influencing protein consumption, hence they may be substituted one for the other. It must be noted that fodders containing considerable fat are difficult to digest and are expensive and therefore should be used with certain discretion. When considering ruminating animals in general, one had better rely upon carbohydrates which most feeds contain in reasonable proportions, and, which within themselves are furnished at a comparatively low cost; furthermore, as they decrease the daily protein consumption, they keep the animal fed in a good healthy condition with a very restricted absorption of nitrogenous substances. Respecting the influence of fat upon a decreased protein consumption, Voit's experiments demonstrate beyond cavil, that the fat when fed alone, rather tends to increase than decrease the protein assimilated. This fat diet appears to have very little influence upon the fat already stored up in the body, and as the fattening of live stock continues, the process of fat deposits is more and more difficult from the feeder's standpoint. Experiments have been made in feeding fat and protein alone. When the quantity of protein fed was the same from day to day and the amount of fat increased, the fat deposited was proportional to this increase. Other combinations showed that the fat deposited from protein was more tenacious than the fat having a fat-like origin. Under certain conditions of disease, large quantities of fat are deposited in the liver and other organs of the body, and it forms at the expense of the protein. It is said that the greatest amount of fat that can thus be formed is 51 per cent. At the New York experiment station, it has been demonstrated that the fat in the food explained the fat in the cow's milk especially during the last half of the feeding period. It is important to note that the fat percentage is very variable in some cases. In these experiments it was pointed out that the fat in question was the so-called crude fat or ether extract which contains other substances such as chlorophyl in the solution. As fat can be formed from carbohydrates, as has been demonstrated for most animals, it is reasonable to suppose that the cow is not an exception. The transformation was thought impossible during the early stages of fattening, but at present it is considered a certainty and it has been well proved by the Lawes and Gilbert experiments that the fatty acids are absorbed and subsequently deposited as fat.

The Pettenkofer and Voit experiments showed that 100 parts of fat were about equal on an average to 175 parts of carbohydrates. The amount of fat in the body is very variable; while in the case of a fat calf it may be nearly 15 lbs. per 100 lbs. live weight, it is 30 lbs. for a fattened ox, and there are two pounds of fat constituents for one pound of lean meat.

Fat exists in the blood in minute quantities, say not more than 0.3 per cent. In the bones and nerves it is found in greater amounts. It is especially found under the skin. Most of the fat cells of a living animal contain transparent fat.

From whatever part of the body the fat is taken, it is almost identical in composition and furthermore, if existing in plants or in the body of an animal, its composition is always about the same, carbon 76 per cent., hydrogen 12, oxygen 11.5.

Experiments relative to the digestibility of fat cannot be considered as entirely satisfactory in their results; they have, however, considerable scientific value for the estimation of the feeding value of a fodder. The poorer the fodder in fat, the greater will be the error committed. While such modes of estimation are not mathematical, they allow one feeding stuff to be compared with another.

The production of fat may be calculated in advance based upon the gain or loss of carbon. To carry on a series of experiments of this kind demands very delicate appliances, in which one may measure very accurately the air thrown off by the lungs and perspiration, etc., besides that found in the urea, etc. On this subject, Armsby says: "If the comparison of the nitrogen in fodder and excrements shows that the body has neither gained nor lost albuminoids, then the carbon gained or lost was all in the form of fat. Every 100 parts of fat contain 76 parts of carbon, therefore every 76 parts of carbon shown by the experiment to have been gained or lost represent 100 parts of fat, or one part of carbon corresponds to 1.3 parts of fat."

According to the old theory, which was that the non-nitrogenous substances had one principal object, namely, to furnish fuel to the body, the comparative value of fat and carbohydrates was determined by the amount of heat easily produced. It was calculated that one pound of fat produces about 2.5 times the heat given out by one pound of carbohydrates. The percentage of fat contained in plants is very variable; for beets it is 0.1 to 0.2, and in certain varieties of corn, it reaches 8 per cent., while certain oil seeds contain 40 per cent. As this is not all extracted during the industrial methods of extracting the oil, there remains a residuum containing 8 to 12 per cent.

Fermentation is the decomposition of varied molecules under the action of ferments. Decay, taken in the general acceptance of the word, is an oxidation. Putrefaction involves the fermentation of nitrogenous substances with the liberation of certain offensive gases. *Acetic fermentation* is the conversion of weak alcohols into vinegar. *Butyric fermentation* is the conversion of butter-fat into butyric acid. *Lactic fermentation* is the decomposition of milk.

Fertilizers are plant foods.

Fibrin. A substance that does not exist in an insoluble state in the circulating blood, but separates in a solid state shortly after the blood leaves the body. It may be obtained by stirring blood as it flows from a living body; the sticks used become covered with a white compound. It is tasteless, and when dried resembles albumin. Fibrin is a proteid.

Forage is a food for horses, but it may be applied to cattle in general and is another name for feed.

Fuel value is frequently measured in heat units or calories. One pound of digestible fat is estimated at 9.200 calories; one pound digestible carbohydrates 4.200; one pound digestible protein 5.860 calories. Knowing the composition of any feeding stuff. such as beets for example, in one hundred pounds there are 86.5 pounds water, 1.12 pounds protein, 10.21 pounds carbohydrates. When these are burned for furnishing energy, work and the maintenance of the body there would result an amount of materials yielding 49.445 calories.

Gastric juice. A secretion of special glands of the stomach; it contains an important ferment known as pepsin.

Germs are a portion of matter, having within itself the tendency to assume some living form; a spore, a seed are examples of germs.

Gestation is the period the young need for their complete development from time of their conception until birth.

Glucose is a substance obtained from starch through the action of a ferment; its varieties are numerous, among which one may mention dextrose and levulose.

Gluten meals and gluten feeds. It is difficult for the breeder to exactly comprehend the difference between these two substances which are the residuum of glucose manufacture, when corn is used as a basis of the manufacture during the process of starch separation from the grain. After a proper soaking, lasting for several hours, etc., there follows a straining through bolting cloths, the germs and hulls being thus separated. The product may be dried and in some cases submitted to a preliminary treatment with naphtha to remove the oil, and this product is known as *gluten feed.* When the final residuum in the settling tanks after the oil is extracted is combined with the germs, it is sold as *gluten meals.* It is to be noted that the latter contain between 24 and 38 per cent. protein and an average of 8 per cent. fat, the former contain 12 to 24 per cent. protein and an average of 12.5 per cent. fat. The introduction of gluten meals and feeds has met with some difficulty owing to the possibility of their containing a certain percentage of sulphuric acid, which might be pernicious to the general health of the animal. The question is open to discussion. The product has at present the approval of most of the leading authorities of the country. The difference between the gluten meals and feeds that must not be overlooked is that the former contain more protein than the latter.

Glycogen. This substance is a carbohydrate and is formed in the liver.

Glycose is another name for glucose.

Gram is equal to 0.035 ounce; it is one thousandth part of a kilogram.

Gullet. In ruminants the passage between the mouth and first stomach.

Gums In rations in general, gums are frequently formed in very small quantities; but in certain cases they must be taken into account. While gums are digestible, modern experiments give very little information as to their nutritive value.

Hectare is two and a half acres (2.5 acres).

Hemoglobin is a crystalline substance existing in the corpuscles of blood, and to which their color is due; it is one of the oxygen carriers in the circulation.

Herbivorous is a name given to those animals that feed on vegetation.

Hydraulic pressing. During the early periods of beet sugar manufacture, the finely divided beet pulp was submitted to the action of hydraulic presses, but these machines have now become obsolete.

Hydroscopic. Property of absorbing moisture from the air.

Intestines. Food during the process of being digested passes in its journey through the body through a final canal, known as the intestines.

Invert sugar is a saccharine substance found in honey; it may be obtained by submitting cane sugar to the action of dilute acids.

Kilogram. One kilogram is equivalent to 2.2 lbs.

Kilogrammeter means the mechanical work capable of raising one kilo to the height of one meter. A horse-power is represented by 75 kilogrammeters produced in one second. On the other hand, 425 kilogrammeters correspond to a production of heat equivalent to a calorie, or the heat necessary to raise the temperature of one kilo of water one degree centigrade.

Kilometer is 0.62 of a mile.

Lactic acid. This product is one of the vegetable acids not to be overlooked in the theory of animal feeding. It is not thought to exist in any vegetable product in a normal state, but is the outcome of some organic and acid transformation. Beets and beet leaves contain this acid, and it is also found in the cossette residuum.

During digestion, it appears to be formed from the carbohydrates; its action under these circumstances is that of effecting certain changes in the phosphoric acid; it penetrates into many of the capillaries and facilitates assimilation of certain nutrients.

Legumin is a proteid compound, and may be considered as a vegetable casein.

Levulose is the sugar found in fruit; it is also called fruit sugar or fructose.

Lime must be added to fodders consisting of beet cossettes, etc. It is needed for the bony tissue of the body, and is very frequently deficient in the composition of most feeding stuffs.

Lime phosphate is a substance formed by the combination of phosphoric acid and lime.

Liter is about 1.05 quart.

Lymph is the fluid in the lymphatic vessels, and is the filtration of the liquid parts of the blood through the tissue of the capillaries.

Lymphatic. Pertaining to the lymph.

Meter is about 3.3 feet.

Methane is to be found in nature, chiefly in marshes, when decomposition of organic substances is in progress.

Micro-organisms are organisms of microscopic size.

Mucous, a term applied to tissues that secrete mucus.

Narrow ration means that the ratio existing between the protein and carbohydrates is small. An example of this is cotton-seed meal, 1:1.2, in which case the protein is nearly equal to the carbohydrates.

New process linseed meal. The process is mainly based upon a naphtha-extractive mode. The meal contains from 26.5 to 40 per cent. protein and an average of 3 per cent. fat. It is to be noted that when its composition is compared with the old process, the oil percentage is less and the protein percentage greater; hence it has of recent years found many general applications. It is very discouraging for its advocates that the old linseed meal appears to be more digestible than the new. This fact may be counterbalanced by the difference in cost in some special cases.

Nitrogenous feeding stuffs.—*Classification.*

A. By-products subsequent to the extraction of oil or starch.
B. By-products from the manufacture of flour, such as wheat bran.
C. Several kinds of seeds.
D. Green and dried leguminous fodders.

Nutrition and excretion. It is through the blood that all nutrition of the body is affected, and when it does not circulate, complications are sure to follow. All transformations of the body are formed and renewed by the blood. In all these modifications, the real action of respiration must never be overlooked; consequently pure air is also a most important question, as without it the burning of the carbon is not satisfactorily accomplished, and the heat of the body not maintained. The element carbon must also be furnished in sufficient quantities; this cannot be done through protein substances alone, but to them carbohydrates must be added, otherwise death is sure to follow. While water is an important question it need not, upon general principles, give much anxiety, because it may generally be had in sufficient quantities.

Nutritive substances, as they first enter the blood, are not in a condition to be entirely assimilated; they must undergo certain changes. Protein substances that at first do not coagulate, later, when acted upon by the various secretions of the stomach, become albumin and fibrin, both of which coagulate. Fatty substances are no longer discernible; they are almost entirely dissolved and completely combined with alkalies as previously explained. The role of the fat in the blood varies as the occasion demands.

Every motion of the body means a certain wear and tear, which is directly proportional to the effort. The worn out tissues are replaced by new ones through the intervention of the blood, due to the combined process of digestion and assimilation. If the animal is growing, allowance must be made, not only for waste, but also for new flesh and bones formed.

The nutritive substances, after being absorbed from the intestinal canal, soon undergo changes owing to their combination with oxygen, the used portions being consequently thrown out in an oxydized condition. This and like interchanges represent the actual vital phenomenon that occurs when heat is evolved or flesh and fat formed. During circulation the oxygen of the air comes in contact with the carbon of the blood to form carbonic acid. The amount of gas formed and carbon consumed may be accurately determined. During the continuance of circulation, the globules themselves carry oxygen through the body. An interesting comparison has been made between the blood circulation of the body, and a river with its tributaries, upon which float boats moving in different directions. On the one hand we have these small boats or globules charged with oxygen floating in albumin, on the other hand the corpuscles floating in the opposite direction carrying carbonic acid, the result of the combination of oxygen with the carbon. During sleep the exportation, so to speak, of carbonic acid lessens, but the importations of oxygen increase, under which circumstances there is a certain amount that is stored up to be subsequently used the next day. The amount of oxygen penetrating the blood is entirely independent of the breathing; but upon the volume needed for the combinations that follow, many factors have an important influence, such as the kind of food eaten, the composition of the blood, etc Evidently, when food consists mainly of protein substances, the number of blood corpuscles is increased. The dividing up of the compounds into simple forms then becomes more complicated, and the oxygen consumed is greater. Experiments by Henneberg upon oxen appear to demonstrate that during sleep they store up a certain amount of oxygen that is transformed into carbonic acid during work. Under these circumstances we know the amount of oxygen, hydrogen and carbon contained in the fodder, and the amount in excrement and the amount deposited in the body. It is possible to ascertain the percentage of each that was consumed in the formation of carbonic acid and water that was subsequently absorbed in the body. The percentage of oxygen taken from the air is determined by the use of the Pettenkofer apparatus described elsewhere. Evidently a certain equilibrium between night and day is, on the long run. established. It must be understood that in these transformations the nutritive elements must first pass through the tissues to enter the circulation and thus undergo a certain dissociation before the combination with oxygen can be complete. It necessarily follows that by reason of excessive work, more tissue is consumed. The oxygen demanded for its burning must also increase. Naturally when the wear and tear is greater than the repair, the animal gets thin. The reverse is also true, and upon this fact the fattening of an animal depends. In regard to this it might be pointed out that in feeding rations, frequent mistakes occur, as when a poor ration follows a rich one. the falling off in fat, etc., represents more money than the value of fodder saved. It takes very much less time to destroy than to build up.

The repair of wastes in the formation of new cells is a very complicated question. The skin, nails, hair, etc.—in other words every part of the body—are being gradually renewed. This wear and tear is evidently very much greater with young growing animals than it is with such as are more fully grown.

The development of the bony frame is most important, and as it is composed of saline principles, the fodder must contain those salts that are requisite to repair loss. Hay and cereals of all kinds fill the required conditions. Once the bones and nerves have attained their full development they undergo very little change. From what has just been said, the importance of phosphates in rations is evident. When an animal has attained its full development, it has a tendency to deposit fat, a condition much desired in the various methods of fattening. A pound of fat meat may bring twice the money upon the market that a pound of lean meat from another animal would bring. Several French experiments by Boussingault and others have demonstrated beyond cavil that carbohydrates are most important fat formers, and when fed in excess of what is needed, they are deposited in the fat cells of the body. This subject is discussed in full in another chapter; however, for the present, we desire to call attention to sugar and its importance. This hydrocarbon is rapidly burned during the process of respiration. The amount of sugar that enters the digestive canal during twenty-four hours is very great, being about 20 lbs. for a full-grown ox, yet the blood itself contains only a small percentage of it. Nowhere does it appear to be deposited and its dissociation is extremely rapid as compared with the assimilation of other elements. In fact, carbohydrates in general are rapidly absorbed. The fatty substances of a fodder help to sustain respiration and aid the production of animal heat; they form a sort of emulsion, combining with alkalies of the pancreatic fluid and bile. The fatty oils when in excess in a fodder frequently produce a bad effect upon the animal's health. This fat formation is always limited. When starch is in excess in a ration, it is always found in the excrement. Fat may be formed from protein substances. Whatever be the source, the excess should undergo a complete oxidation, and the amount that has been deposited either as fat or in milk, depends upon several conditions too complicated to be considered in this writing. An interesting fact that is difficult to explain is that fat deposited from albuminoids oxidizes more rapidly than the fat that had been previously deposited from other sources. We cannot pass unnoticed the action of glycogen, which may also be considered a carbohydrate. This element is found in the liver in quantities depending upon what the animal eats; its properties are very like sugar, as regards its effect upon polarized light, but it has no action on a copper solution. This sugar appears to be constantly renewing itself, but the process is not known. Within what limits this glycogen is a reserve for the sugar needed by the body would be difficult to say. The carbohydrates appear to play their most active parts during the last period of fattening. The direct action of the elements of this group is understood to a reasonable extent, but there are many facts relating to it that continue to remain a mystery. It is unnceessary to enter into the various theories that attempt to show that glycogen has a protein origin, being held in reserve until needed.

In all questions of nutrition, the nervous system takes a most active part, but what precise action foods have upon the nervous system continues to be open to conjecture. We do know, however, that certain foods are more exciting than others, this action varying in each special case; just as very nervous individuals are seldom fat, so are nervous animals most difficult to fatten. A problem of the future will be to discover some food that can, in a measure, overcome excessive nervousness. The question remains to be decided whether by proper care a new race could not be created in which the characteristics of the ancestor could be overcome; but as matters now exist, the complication, whatever it be, has a tendency to increase, and until diminished, the science of cattle feeding must suffer from the want of more accurate methods. The rational system is kindness and due consideration for the animal under special observation. It is interesting within a reasonable extent, to follow the various elements not yet assimilated which have been taken up by the blood; their separation is effected by special organs known as glands, all of these having special functions to fulfill. It is well not to confound the glands that excrete with the organs that secrete. For example, at certain periods at the end of gestation certain glands forming part of the udder excrete a fluid called colostrum (rich in salts and albumin). This had previously been a yellowish mucus, later was made up of a series of fat or milk globules, and changed its condition just previous to the birth of the progeny. The fat globules do not hold together, and later, when the actual milk has been secreted, the colostrum globules disappear to be replaced by regular milk globules, surrounded by a thin covering of casein, that are very numerous until the calf is weaned. All milk, whatever be its source, contains enough nutrients to sustain life.

The evaporation from the body or perspiration is one of the most important forms of excretion, and is more complicated than many suppose. Besides watery vapor, carbonic acid, acetic and lactic acids, certain special organic and inorganic substances are present, sodic chlorid, phosphates, etc., being found among the latter. The oily matter thrown off through the skin is excreted by special glands. In a full-grown ox, this excretion attains considerable proportions. Experiments of Henneberg and Hohmann show that this water evaporation through lungs and skin can reach 22 pounds per diem. During this excretion very little nitrogen escapes in the same direction. On the other hand, Grouven shows that considerable ammonia is thrown off. The carbon escapes mainly through the lungs, but much is also excreted through the skin in the form of carbonic acid, as previously mentioned. The hydrogen combining with oxygen is eliminated mainly in the form of water. The most important excretion of the body is done by the kidneys through which the blood passes. In these the nitrogenous substances formed by the decomposition of the albumin of the body are removed. The secretions from the kidneys are received in the bladder before being expelled from the body. The most important element in the urine of cattle is urea, a substance very rich in nitrogen, also hippuric acid which corresponds to uric acid in carnivorous animals, the inorganic substances being alkaline bi-carbonates. Phosphoric acid appears to be absent from the urine of cattle. Urea is rapidly eliminated from the blood in a healthly animal under which circumstances it is not deposited. When the deposit does occur, there is something faulty in the working of the organs, and complications, such as rheumatic gout, are sure to follow. In a good healthy full-grown animal the amount of urea thrown off per diem attains about one pound in weight.

Urea crystallizes easily and is soluble in water. During the phenomenon of osmosis, these crystals pass in and out with great ease. Henneberg says that the 33.5 parts of nitrogen contained in 100 parts of anhydrous albumin may be separated as urea. The remaining albumin combines with 12.3 parts water to form 51.4 parts fat and 27.4 parts carbonic acid. The amount of urine excreted varies very much with the animal and the kind of food used, some individuals having greater power of assimilation than others. Upon general principles, it may be admitted that the richer the fodder is in protein substances, the greater will be the quantity of nitrogen in the urine. Protein substances when fed in excess of actual requirements should be eliminated entirely, but this is seldom the case. In fact, as previously explained, the theory of cattle feeding depends largely upon the subject of excretion, and the influence of a ration upon an animal may be thus determined to a nicety. Great care should be taken to collect every drop of urine, as numerous important experiments demonstrate that all the nitrogen that has been separated from the albuminoids during the process of assimilation is found in this excretion. In such experiments, there is always a certain loss of nitrogen that is difficult to account for; it is very small, and is, in most cases, supposed to be due to faulty methods of analysis. Consequently every effort should be made to absorb the urine by a suitable amount of straw. What has just been said applies not only to cases where the excrement is to be analyzed, but also when it is to be used as a fertilizer.

We may conclude that a rich fodder offers a double advantage to the farmer. On the one hand there is a gain in flesh, and on the other the quality of manure obtained is better. An interesting calculation might be made showing that it is not always cheaper to purchase manure than fodder. It has time and again been demonstrated that it is possible to purchase feeding stuffs and combine them in a suitable ration, so as to feed for maintenance, and not obtain an increase in weight but yet obtain manure as cheap as if purchased direct from a neighboring farm. Consequently, no well organized farm should be without a certain number of cattle, whatever be the advantage of a chemical fertilizer; for there is always a factor, small it is true, but yet felt after a term, that chemical fertilizers do not furnish. When it is a question of beet pulp feeding, this is especially true; the elements that are deficient may be supplied at a nominal cost.

Nitrates. Very little attention need be given to nitrates, as they are considered to be without nutritive value.

Nitrogen-free extract. Contains starch, sugar, gums, pentosane, etc., after deducting from the total dry matter the ether free extract, crude fibre and ash. If to the nitrogen-free extract we add the crude fibre, we obtain what is generally termed carbohydrates. There is a great difference in the nitrogen-free extract of different fodders. For example, in rye flour it is 70 per cent., while in certain corn roughage it is only 12 per cent. Experiments appear to prove that all the nitrogen-free extract, that may be actually digested, has about the composition of starch; consequently the non-nitrogenous substances, with the exception of fat, may be considered as carbohydrates. A portion of the nitrogen-free extract is not digested. An important point to be noticed is that the amount of crude fibre digested is nearly equal to the amount of nitrogen-free extract that is not assimilated. This principle must not be accepted to the letter; but it enables one to form an excellent idea of the digestibility of a fodder. Experiments appear to show that the undigested nitrogen-free extract has more carbon in its composition than carbohydrates, and is said to have the same as lignin.

Non-nitrogenous. The most important of the non-nitrogenous nutrients of which fodders consist are the carbohydrates, fat and cellulose.

Non-sugar. Any feeding substance containing sugar has combined with it other constituents which are, in general, termed non-sugar.

Nutritive ratio. This expression is very practical. In its proper sense it is intended to convey the ratio between digestible protein in any feeding stuff and the amount of digestible carbohydrates and ether extract. This ether extract is multiplied by 2.4. (In the United States there is great need of some uniformity in the use of this factor, as in some cases it is 2.2 to 2.25 and in others as high as 2.5; the latter is an excess and the former too small.) If we consider red clover hay, for example, there will be, for one hundred pounds of this fodder, 6.8 lbs. protein digestible, 35.8 lbs. carbohydrates and 1.7 lb. of ether extract. The ratio is calculated as follows:

$1.7 \times 2.4 = 4.08$. The total carbohydrates then are: $35.8 + 4.08 = 39.88$.

$$\text{Nutritive ratio} = \frac{39.88}{6.8} = 5.8 \text{ or } 1:5.8.$$

Oil meal. In most countries of Continental Europe the various after-products from oil mills are known as oil *cakes.* In the United States the product is ground to a meal, hence the name oil meal. It offers great help for feeding in general; but the quantity used should be restricted.

Oil process linseed meal. The "oil cake," as it was once called, has now practically become almost obsolete. The cakes containing 15 per cent. oil were of comparatively small dimension and easy to handle. In consequence of the increased pressure to which the residuum was submitted, the oil percentage diminished, and now the name has been changed to "old oil-seed process." The original oil cake in many countries continues to hold its own. In the United States it renders considerable service in compounding rations for horses. Not more than two pounds per diem should be fed. It offers in special cases an advantage as a laxative. The old process product contains a protein percentage that may vary from 26 to 38.5 per cent., and an average of only 8 per cent. fat.

Omasom. This is the third stomach of ruminants.

Organic matter. When feeds are burned the organic matter disappears.

Osmotic action. That which pertains to osmosis.

Osmose. When crystalline substances are in solution, and are placed in porous receptacles, they pass through, leaving the particles that are non-crystallizable, or colloids.

Oxalic acid. This acid is found in the juice of numerous plants as potassium or calcic salt; it is mainly the outcome of the oxidation of various substances. It may be prepared by the simple action of nitric acid upon sugar.

Paunch. The largest division of the stomach of ruminants is called the paunch or first stomach.

Pea meal comes under the head of the legumes. Its use is not very general. It may contain 20 per cent. protein and an average of 15 per cent. fat. Combined with roots, it is frequently used in feeding, and then offers special advantages. It excels all split peas.

Pectic substances. The composition of these products is very variable. They are found in beets and other roots in the form of pectose. When boiled this becomes pectin, and if the heating continues, there is formed pectic acid, etc., which acid is insoluble in boiling water; when the boiling is continued, there is formed a metapectic acid. As these simple and complex bodies are digestible, they play important roles in animal feeding. Just what relation exists between them and carbohydrates remains to be demonstrated; they differ from carbohydrates in their percentage of oxygen.

Pentosanes are found in considerable quantities in plants. The pentoses, the outcome of pentosanes, are hydrocarbons.

Peptones. Constituents found in sugar beets as well as in other roots, etc., and are also formed from protein during the function of digestion. It remains to be demonstrated just what their role is, and, consequently, what advantage there is in having them in fodder.

Phosphates. Phosphoric acid combines with alkalies to form phosphates.

Phosphoric acid. In many fodders phosphoric acid is very deficient, and should be added in one form or another. The percentage of this chemical in plants varies very considerably. In beets and residuum cossettes, this acid may frequently be found in sufficient quantity to meet the demands of the bony tissues.

Plant foods. Plants, during their growth, take up from the soil certain elements, such as nitrogen, phosphoric acid, potash, etc., which are the foods upon which their development largely depends.

Protein. Represents a compound consisting mainly of nitrogen. Just how it is formed in plants is explained by the action of nitric acid and sulphur upon the protoplasms of the cells of plants. After a certain period, the protein appears to leave a certain portion of the cellular tissue and centers itself in the seed and mainly in the germ. The protein compounds may be divided into two groups, albuminoids and amides; they constitute the most important elements in feeding, and therefore should be the most expensive. The transformation that these protein constituents undergo during assimilation consists in the formation of muscles, bones, skin, etc., which action may be for the purpose of replacing waste, or to help build up and increase tissue. The mode of determining the percentage of protein in any feeding stuff, is too complicated for the present writing. Suffice it to say that after the nitrogen has been estimated, the amount is multiplied by 6.25, and this, for all practical purposes, represents the protein. The amount of protein in feeds varies considerably; 100 lbs. of clover hay contain 12 lbs. protein, while sunflower-seed cake contains per 100 pounds nearly 33 lbs. protein. Between these two there is a long series of fodders. Upon general principles, it may be admitted that nitrogenous substances during the process of assimilation in the body are transformed into soluble peptones, which find their way into the blood. The protein energy of one gram of this substance is 4.1 calories or 6.3 foot tons. Feeding experiments with protein appear to show that when used alone it tends to increase the consumption of the protein of the body. and the excess does not appear to help the formation of flesh. This question is still open to discussion. Some well conducted experiments appear to show that when the ration used is a wide nutritive one, the results obtained are more satisfactory; hence the best mode appears to be to combine the protein required with considerable carbohydrates. Various substances have important influences on protein consumption. It is now admitted that amides contained in plants can justly claim to be nutrients, and are oxidized just as other feeds are; for example, asparagin when fed in certain quantities will result in a gain of protein even when forming part of a ration poor in protein. Under these circumstances it becomes a helper in the formation of tissue. Later experiments show that amides may also take the place, within reasonable limits, of albuminoids.

Without doubt sodic chlorid or salt has an important influence on protein consumption; the general circulation of the blood being stimulated through this saline action, there necessarily follow greater wear and tear, and consequently a demand upon the existing protein. A fact not to be forgotten is that salt increases the working of the kidneys, and acts in a measure as a diuretic. The flow of urine being greater, there follows a certain thirst, and if this cannot be satisfied, the requisite water will be drawn from the body, under which circumstances there is a drain on the tissues; hence the desirability in such cases of considerable water for drinking purposes.

Many experiments tend to show that the glycogen in the liver derives its source mainly from protein, that it is thus stored up and used when required. There are numerous other theories of the same kind.

Abstinence from food demands that the body meat (muscle), shall be called upon, and under these circumstances there follows a considerable daily decrease of protein. Voit's experiments show that protein exists in two forms in the body, viz., the organized protein and the movable protein, but such theories have since been refuted. The bulk of existing experiments appears to show that they are truly scientific in the proper sense of the word. The organized protein undergoes a change very slowly, while the movable protein is rapidly decomposed into its albuminoids, and must be replaced by the protein contained in the fodder. In feeding fodders to sheep, experience seems to show that there is every advantage in using considerable protein to obtain the best fattening; it tends to increase the amount of nutrients digested. Protein also plays a most important role in milk production, in helping the growth of the cells in the milk glands, as they consist mainly of protein. The importance of this element in the food is very readily understood; furthermore, the greatest yield in milk in most cases is in direct ratio with the supply of protein. This substance tends to increase the percentage of solid matter in milk. In certain special cases, if the food is especially palatable to a cow, the flow of milk may increase without additional protein, but there is then danger of the animal drawing upon its reserve force, which always means a considerable reduction in weight, and a reaction is then to be dreaded.

Potassic salts. Fodders in general contain these salts in sufficient quantities; hence they need not be added to the ration.

Pressed cossettes. After the beet slices have been sufficiently exhausted of their sugar in the diffusion battery, they are emptied from the bottom of the diffusors, and as they contain an excess of water, which would render their handling most difficult, this is very considerably eliminated by running the residuum through special presses, known as cossette presses.

Proteids. This is a general term given to the albumin and albuminoids entering the composition of feeds or the organism. There are many subdivisions of these substances, such as egg albumin, serum albumin, etc.

Pulps is another name for diffusion residuum cossettes. The term is very generally used, and may be accepted. However, a pulp obtained from beets exists only in beet distilleries, where, after fermentation, the final residuum is an actual pulp. When hydraulic pressing was in vogue, the beet residuum was a pulp in the true sense of the word, but now the final product, after leaving the presses, has a certain tenacity, and is not soft and pulp-like.

Radiation. The emission of rays of light or heat; to shine.

Ration. The daily allowance of food for an animal must be made up of nitrogenous, non-nitrogenous and mineral substances. While most fodders, either dry or green, contain these in varied proportions, they seldom, when considered alone, constitute what might be termed a complete food, meeting the daily requisites. In order to maintain an animal in a good healthy condition, several fodders must always be combined to make up the ration. Practical experience shows what these combinations should be.

Recticulum. This is the second stomach of ruminants.

Rennet or Abomasom. This is the fourth stomach of ruminants, in which take place the processes relating to digestion.

Residuum. After an operation having in view the extraction of one substance from another, there remains a residuum. In the extraction of sugar from beet slices, there remain the cossettes, which are known as residuum cossettes. There are various other residuums left in beet sugar factories, such as filter press residuums, also termed filter press scums, and there is also the water residuum from various appliances.

Roughage is the coarse portions of a ration, such as hay, corn, fodder, silage, straw, etc.

Ruminants. The animals that chew a cud are known as ruminants. The stomachs of the leading members of the group have four separate divisions.

Saliva is a secretion from the glands of the mouth. It not only moistens foods, but in an important measure helps in the subsequent digestion.

Saccharose is another name for cane sugar.

Scums. During the filtration of carbonated beet juices there remain, upon the filtering cloths deposits called scums, which consist not only of carbonate of lime, but also of the coagulated albuminoids that rise to the surface of saccharine juices during their heating and carbonation.

Serum is a fluid, yellow in color, which separates from blood after the fibrin has coagulated.

Silos. The pit or combination by means of which feeds are kept during the winter months. They may be above or beneath the surface. Beets and residuum cossettes, after being arranged in piles, are covered with earth and straw.

Sodic chlorid is another name for common table salt; it is also called chlorid of sodium.

Sour cossettes are those cossettes that have been siloed and have undergone a partial fermentation. Their flavor is very much more acceptable to live stock than is either the fresh or dried residuum.

Stalks of beet seed. During the second year of the beet's development, it throws up stalks upon which the seeds are formed; these stalks and old seed are frequently used for feeding purposes.

Starch. This product is found in considerable quantities in all vegetables. One of its essential properties is that when brought in contact with iodin, it becomes blue. It may be changed to dextrin by boiling with acids, and when placed in the mouth or in the stomach, it is changed into sugar. It plays a very important role in the non-nitrogenous substances. and is very readily digested. Its general composition is nearly that of cellulose. Starch swells in boiling water. The product exists in plants in the most varied form. When heated it may be changed to dextrin.

Stimulants. In most cases stimulants are of the first importance in cattle feeding. When mentioning stimulants, we refer to those substances that have for their object the increase of appetite. The importance of salt was for many years doubted. but we believe that it is now accepted by most experts. It stimulates the digestive glands to secrete actively and thereby renders excellent service. Pleasant and comfortable surroundings has in all cases a stimulating effect not to be overlooked, and the same may be said of kind treatment. A farmer who brutalizes his animals is in the long run the loser; the irritating effect produced by his presence has anything but a stimulating effect upon the cattle under his care. It frequently happens that the entire nervous system is affected by the regular feeding of stimulants that the animal relishes and looks towards eating at regular hours. Many products have been recommended and used, but most of them are too expensive to have any practical value.

Sucrose. Cane sugar is frequently called sucrose; it is made up of 12 parts carbon, 22 parts hydrogen, and 11 parts oxygen, and has for its formula $C_{12}H_{22}O_{11}$; it differs from glucose by only one equivalent of water, water being expressed by H_2O; that of glucose then is $C_{12}H_{24}O_{12}$. If on the other hand,

H_2O is removed from cane sugar, we have starch. These all come under the one general head of carbohydrates.

Sugars. Fodders contain sugar in various forms. Whether from the sugar cane or the sugar beet, it comes under the caption of cane sugar. In certain cases when milk is used, one has milk sugar, and grape and fruit sugars are also to be considered in certain special feeding experiments. Whatever be the kind or variety of sugar, it always, upon general principles, has an important resemblance to cane sugar. Sugars are soluble in water, hence they possess great facilities for being digested, and consequently assimilated.

Sugar in most plants diminishes as they approach maturity, while during the first year, at least for sugar beets, the reverse is the case, when the roots have not been properly siloed. The sugar percentage in beets depends upon their variety, method of cultivation, soil and fertilizer—when nitric fertilizers are used in excess, the sugar percentage is low. Beets that grow above ground contain less sugar than such as grow well beneath the surface; among them may be mentioned mangels, etc., frequently cultivated for stock feed. Upon general principles it may be admitted that fodders containing only a small percentage of sugar are eaten with avidity. It may be admitted that sugar tends to increase the flow of milk, gives strength to the body, and also helps to increase the formation of fat. During digestion all sugars are transformed into glucose.

Wheat bran. This residuum contains very little flour; it renders considerable service for mixing with pulp fodders, and is very extensively used for dairying purposes. It contains about 15.5 per cent. nitrogen.

Wheat middlings are supposed to be the coverings of wheat following the hulls, and include colored flours; in reality there is always considerable flour combined. This is not an advantage in cattle feeding, for various reasons.

Wheat residuums are numerous: wheat feed, ship stuff, flour feed, wheat shorts. They are frequently combinations of several feeding stuffs, such as oats, corn, etc. Their composition is most variable; it is better to have them analyzed before using.

Wide ratio means that the ratio existing between the protein and the carbohydrates and ether extract combined is excessive. For oat straw it is 1:33, which may be considered as an excellent example of a wide ratio.

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